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JOURNAL

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Contents

625 **Britain's engineering manpower**

626 **University course in electrical machines**
by A. J. O. CRUICKSHANK, B.SC.(ENG.), PH.D., MEMBER

629 **British Railways electrification conference**

630 **Developments in air traffic control**
by B. J. O'KANE, PH.D., B.ENG., ASSOCIATE MEMBER

634 **Cablefilm**
by C. B. B. WOOD *and* I. J. SHELLEY, ASSOCIATE MEMBER

638 **The Incorporated Benevolent Fund: Annual Report**

639 **Reliability of electronic equipment**

640 **Improved dielectrics by means of high-energy radiation**
by F. B. WADDINGTON, B.SC.

644 **Advisory Council on Scientific Policy**

645 **Design of lightning-proof h.v. transmission lines**
by A. K. BHAUMIK, B.SC.(ENG.), MEMBER

646 **British Conference on Automation and Computation**

647 **Correspondence**

649 **The XIIIth General Assembly of U.R.S.I.**

651 **Meeting of the Council of The Institution, 6th October 1960**

652 **A review of the *Proceedings*, Parts A and B**
(details are given in the adjoining column)

660 **Papers and monographs published individually this month**
(details are given in the adjoining column)

662 **Contents of the current *Proceedings***

662 **Obituary**

664 **Some recent books**

667 **The metre and the second**

667 **British Nuclear Energy Conference**

668 **Library accessions**

670 **Elections and transfers**

671 **Forthcoming events at Savoy Place**

671 **District Meetings**

672 **Announcements to members**

675 **Bulletin of the Sections**

677 **News from the Centres**

680 **Officers of The Institution**

BACK COVER **Index of advertisers**

652 A review of the *Proceedings*, Parts A and B

New sound-broadcasting headquarters	F. Axon and O. H. Barron
Telephone echo tests	D. L. Richards and G. A. Buck
Electricity meters	G. F. Shotter
Non-reflecting waveguide tapers	Prof. H. E. M. Barlow
H_{10}-to-H_{20} mode transducer	C. C. Eaglesfield, Y. Klinger and L. Solymar
Recording of single-shot phenomena	F. E. Whiteway
High-resolution measuring system	B. J. Davies, R. C. Robbins, C. Wallis and R. W. Wilde
Paraboloidal reflectors with axial excitation	A. R. Donaldson, I. P. French and D. Midgley
Scatter-propagation measurements	G. V. Geiger, N. D. La Frenais and W. J. Lucas
Emission from miniature hollow cathodes	A. Sandor
Experiments on matrix cathodes	A. Sandor
Magnesium-oxide-coated cathodes	H. N. Daglish
Television transmitting aerial in populous area	G. D. Monteath, G. H. Millard and D. J. Whythe
Electron-beam parametric amplifier	G. O. Chalk

660 Papers and monographs published individually this month

PAPERS

Ageing of oil-filled cable dielectric	P. Gazzana-Priaroggia, G. L. Palandri and U. A. Pelagatti
Oscillating synchronous linear machine	E. R. Laithwaite and R. S. Mamak
Silicon power rectifiers	A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams
Theory of depreciation of engineering plant	D. Rudd

MONOGRAPHS

Three-phase series commutator motor	O. E. Mainer
Algebra and topology of electrical networks	P. R. Bryant
Surge corona discharge	R. Davis and R. W. E. Cook
Temperature rises in electrical machines	B. J. Prigmore
Indeterminacies of measurements	R. Madden
Calculation of inductance and a.c. resistance	R. S. Mamak and E. R. Laithwaite
Distortion of random signals in servomechanisms	Prof. J. C. West, J. L. Douce and B. G. Leary

ELECTRIFYING BRITISH RAILWAYS

THE term 'lively modernism' has been applied to the subject of this month's cover illustration, Harlow Town Station. In this new station, through which, we are told, the electric train service on the Liverpool Street—Bishop's Stortford line will begin to flow on the 21st November, the basic idea is to keep passengers and parcels separate. Passenger facilities are concentrated on the bridge spanning the platforms.

A brief report of the British Railways electrification conference held in October 1960 appears on p. 629

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 6 NUMBER 71 NOVEMBER 1960

BRITAIN'S ENGINEERING MANPOWER

An important problem constantly facing those responsible today is the compilation of statistics of the engineering manpower of Great Britain. Anyone who has attempted to compile statistics, or even to complete the census forms so frequently circulated, realizes how difficult it is to make these returns and still more difficult to classify and analyse them.

Even today, the terms scientist, engineer, technologist and technician are variously applied or misapplied, and piecemeal estimates of future requirements seldom sufficiently distinguish between the immediate shortage and the long-term build-up of manpower necessary to support an expanding industry. And yet reliable statistics are very necessary if one is to ensure the availability of future manpower.

Some of the most reliable data on the growth of professional manpower in the electrical industry are to be found in the membership records of The Institution, and it would appear that insufficient use is made of this most valuable source of information. It is known, from other records, that the growth of the British electrical industry has been between 6 and 8% per annum over the past 50 years, and the Institution membership records show clearly the rate of growth of professional manpower needed to support this industry.

While reliable statistics are available on the rate of growth of professional manpower, no such records are available of technicians in the industry, and in view of the growing importance of our technical manpower this is to be regretted.

Incomplete or inaccurate statistics lead to erroneous comparisons and misleading conclusions in a recently published survey 'Britain's scientific and technological manpower'.* In comparing the engineering manpower of America and Great Britain the author is not comparing like with like.

A study of the data in the survey shows that included as 'qualified' American engineers are all 'engineers' over the age of 20 who have a first degree of an American university and some 18% of the total who made no returns of their technical qualifications. For comparison, British 'qualified' engineers number only the Corporate members of the British professional institutions, whose average age of election or transfer in The Institution of Electrical Engineers is 31 years.

Again, the American technicians in the survey include all those in the American industry with four years of high school or less and those with one to three years at college who did not take a first degree. For comparison, the British figure for technicians includes only holders of Higher National Diplomas and Higher National Certificates.

Even if one accepts that any holder of a first degree of an American university might be granted exemption from the education requirements of The Institution (and this is far from being the case) and simply makes adjustments for comparable age groups by including Graduate members in the British total, the comparison looks very different, as can be seen from the Table below. In this Table the number of technicians accredited to Great Britain includes those estimated to be in the British electrical industry at present who have sat for Ordinary National Certificate or Ordinary National Diploma, excluding all who have taken H.N.D. or H.N.C. with endorsements.

Manpower in electrical industry	1950	1956
United States		
engineers	61290	98327
per 10000 of population	4·0	6·4
technicians	45000	73000
per 10000 of population	3·0	4·8
Great Britain		
engineers	26000	32000
per 10000 of population	5·2	6·4
technicians	22000	37000
per 10000 of population	4·4	7·4

The revised figures, which are certainly conservative, show that the British manpower per 10000 of population is at least equal to the American for professional engineers and exceeds it for technicians. It is, therefore, manifestly incorrect to say, at least of the electrical industry, as the author does in his Chapter 2, that 'Britain's deficiency of qualified manpower is thus primarily a deficiency of engineers and technologists'.

The difficulty in the past has been that British technological manpower has been too widely dispersed in units too small to compete with the larger industrial units of the United States. There has been a marked trend over the past years, and in some industries with direct Government intervention, to create larger units which can support research and development effort more in keeping with modern demands.

But perhaps the greater danger in the conclusions drawn from the statistics, as they are presented in the survey, lies in the suggestion that Great Britain must deflect effort from fundamental research to boost its applied research and engineering effort. There is real danger in accepting that Britain is weak in numbers and quality of engineers when the difficulty in fact lies in the fragmentation that arises from the structure of the British industrial organizations.

What the British need to do is to press on with fundamental research, in which lies their great national strength, and at the same time find ways and means of making more efficient use of their engineering manpower at all levels.

* PAYNE, G. L. (Stanford University Press, 1960)

University course in electrical machines

621.313.1 : 378.1

The present interest in remodelling university courses in electrical machines and power engineering stems from the need to correct the unbalance of student interest, which has recently been predominant in electronics. It is also necessary in order to provide a broader scientific basis on which rests the operation of many types of electromechanical device and from which future advances can be made. This article makes suggestions for such revisions.

It is based on certain sections of the Chairman's Address given by the author to the North Scotland Sub-Centre at Dundee on the 29th October 1959. Dr. Cruickshank is in the Department of Electrical Engineering, Queen's College, Dundee, University of St. Andrews.

A. J. O. CRUICKSHANK, B.SC.(ENG.), PH.D., MEMBER

Few of us have not heard the recurringly expressed view that for some years past there has been an insufficient number of graduates entering the power or machine side of electrical engineering, and few of those actively concerned with engineering education would dispute the poor-relation part, in comparison with electronics, which this branch plays in the field of postgraduate research. It may be argued, perhaps, that there have been signs lately which indicate that the worst part of these doldrums may be past, and to be quite fair we should assess the activity in any particular field in relation to the over-all trends and demands of the age. But even allowing for these effects, there is none the less unmistakeable evidence that the present status of power engineering in the universities is inferior to that of electronics. Is the present state of affairs to be debited entirely to the trend of the age; or has something been lacking in the education given in power engineering, the accumulated effects of which are only now being felt? Probably this is so, but, at the same time, it is clearly not the only factor.

Certainly one other influence which makes the light-current side at present more attractive to students is that, in electronics more than in power engineering, it seems possible for graduates to play, very early in their career, an individual, responsible and distinctive part in project development. This is a powerful inducement. Also, the existence of a substantial amount of lively postgraduate research work in electronics is an incentive to students, particularly to those of high intellectual calibre, to enter this field. But surely this drives us back to our original point, for lively research work is the outcome of a broad, scientific, imaginative and virile undergraduate course. If the charge has been made and is now admitted that past courses in power engineering (and a substantial part of these is concerned with electrical machines) were lacking in imagination, breadth and scientific unification, what steps must we take to correct the situation?

Need for changes

Attention has been focused on this question for some time. In 1957, Bell[1] wrote a letter to the *Journal* making substantially the same observations; and in the works of Kron[2], Gibbs[3] and Adkins[4] we have examples of unified machine analysis at two clearly distinguishable mathematical levels. In the United States the need for changes in the established power-engineering curriculum was recognized, and at the Massachusetts Institute of Technology a remedy, if perhaps a rather drastic one, was applied in the autumn term of 1954. Discussions on the subject have recently been promoted by this Institution and by various bodies in the United States. So what is at present under investigation by those interested is not the advisability or inadvisability of changes, but what those changes should be. Further, in certain universities in this country, unified machine theory has been taught at honours-degree level for some years.

Can this broad approach be brought forward in realistic and understandable terms to ordinary-degree level? For it is usually at that stage that students for whom an option is possible choose between the light- and heavy-current sides, and in doing so bear in mind the introduction to machines already given to them. Or, supposing that a simple unified exposition can be made, is this by itself sufficient, or what additional matter is necessary? The author believes that such changes are not only possible, but, in conjunction with a general broadening of the course, highly desirable.

Before considering this further, it is as well to look at the problem in general terms.

Unified machine theory

It is now a quarter of a century since Kron first published his ideas on a unified machine theory. Yet it is only within the last ten years or so that there have been signs that most of these ideas will ultimately be accepted, and it is probably only within the last few years that there has been any movement towards teaching the general theory at some universities. The tendency has been to regard such material on the whole as being more appropriate to postgraduate study; and indeed, in the manner in which Kron and some of his interpreters have presented the theory, such an

estimation has some truth in it. Moreover, to engineers generally, one of the less attractive features of such a treatment is its high degree of abstraction. One likes to feel, as it were, closer to the machine, its materials and their interactions, and a less abstract approach would have the double virtue of being simpler and, thinking in terms of physical interactions, much more interesting. Adkins has made a start to such an approach.

But acceptance of general machine theory is not by itself sufficient to provide a course of adequate breadth, imagination and attractiveness. The whole machine concept must become enlarged to include, in addition to the many common types which industry utilizes, those which are not so common—hysteresis and reluctance motors, limited-movement motors, machines giving linear, rotational and intentional oscillatory motion, relays, solenoids and other devices—or, in short, all configurations of electrical and mechanical elements in which a conversion of energy takes place from the electrical to mechanical form and vice versa. And we should couple with this a study of electrical/electrical energy conversion such as occurs in transformers, frequency changers, rectifiers and related apparatus. In this study, not only should we tackle the great bulk of linear phenomena, most of which can be fairly easily incorporated into general theories; but also recognition of the fundamental and valuable properties of non-linear systems in the fields of frequency changing, oscillation and control should be promoted by studies of adequate depth.

Solid-state engineering

Many of the advances in machine development which industry has given us recently are those which depend on the exploitation of the physical properties of new materials. The study of materials and of the effects of molecular structure on physical properties should receive an attention commensurate with this fact. Indeed, one might predict the early emergence of an engineering discipline intermediate between electronic engineering and power engineering—a branch which might be termed solid-state engineering—devoted to the study and production of materials, conducting, semiconducting, insulating and magnetic, designed to have physical properties suitable for particular applications throughout electrical engineering.

In all energy-conversion apparatus, the dielectric and magnetic circuits merit proper scientific study, as well as subsidiary mechanical forces and the problem of heat conduction. This integration of several fields of study must surely provide sufficient intellectual challenge and interest for anyone. What does emerge, however, is that studies of such breadth can be encompassed successfully within the normal three-year course leading to an ordinary degree only by careful planning throughout the whole. It is important to remember that the study of machines forms only a part of the whole course, and that changes in any one part have limited effects in other fields.

A modern course in electrical machines

Turning now to the specific problem of designing a suitable, modern final-year course in electrical machines, it is as well to remember that this often represents the first contact of any depth with machines, and therefore, as far as possible, the approach should be fundamentally physical and related to actual machines. Naturally, the presentation should be unified and broad. Abstraction should be avoided, but, it should be noted, this does not imply that mathematics should also be avoided. The whole point is that one should not lose any opportunity of showing, first, how the materials of machines interact from a physical point of view, and, secondly, how groups of physical interactions may be taken together and given mathematical description.

The M.I.T. treatment is somewhat in conflict with this viewpoint. It is largely surgical and abstract. Surgical, since, according to their recently published class text[5], nearly all the material bearing a resemblance to a.c. and d.c. machines has been cut out of the compulsory part of the programme, and is now described in the preface as specialized material appropriate to either postgraduate work or an optional subject to be taken in the last term only of the whole four-year course, if desired. Abstract, since what remain after this removal of many important physical phenomena of machine operation are mathematical transformations, not machines.

Is the condition really so grave that the best course is to remove practically all the internals? Opinions obviously differ, and no doubt controversy will continue. But, on the whole, I believe engineering students are not addicted to abstraction and may well be discouraged by an abundance of it. Also, to proceed from the particular to the general does not, I think, indicate paucity of intellect, but, on the contrary, such thinking constitutes a vital intellectual discipline without which real appreciation of a general theory is not possible.

To make specific proposals is to invite criticism. However, I suggest a course could be built on the following lines. These relate to a final-year programme which may be followed by an honours year. No consideration is given here to this later year.

Electrical/electrical energy conversion:
- magnetic coupling
- conductive coupling
- voltage, current, phase and frequency transformation, magnetic amplifier, rectification and inversion

Electrical/mechanical energy conversion:
- singly and multiply excited magnetic and dielectric circuits
- flux distributions
- limited-, oscillatory- and continuous-motion devices, rotational and linear

Rotating machines:
- e.m.f. and m.m.f. relations in uniformly wound machines
- generalized rotating machine
- d.c. and a.c. machine equations

simple transients, frequency responses and linear oscillations

Physical phenomena:

commutation, saturation, harmonics, heating, subsidiary forces, electric stresses and losses

Operational principles:

control systems, starting, parallel running and measurement.

An outline such as the above, unfortunately, cannot convey the real character of any course, the details of presentation of which would require a discussion outwith the length of this article. Possibly the ground is too extensive for an 80-hour lecture course, but any temptation to omit what might be termed the less important parts from the industrial-usage point of view should be resisted. The whole point is to widen horizons and hope that in time new developments and wider applications will result.

Accompanying changes

There are, of course, changes in related fields which are necessary to supplement proposals such as the above. The first and obvious accompaniment is a laboratory programme of broad scope directed generally to the evaluation of machine performance in both transient and steady-state conditions and having a minimum amount of set experiments. Modern measuring techniques requiring oscillograph photography, analogue computers and specialized electronic instruments for obtaining precision speeds, phase angles, transient torques and so on should be introduced. There is no basic difficulty in achieving this, but it is liable to make heavier demands on teaching staff.

The second desirable feature is the provision of more intensive study, as at M.I.T., of fields and materials. All materials, magnetic, conducting, semiconducting and insulating, should receive proper study, and serious attempts should be made to correlate the molecular properties with their macroscopic properties. The relationship between field theory and circuit theory should be fully examined. This study forms the core of what was referred to previously as solid-state engineering.

The third item is possibly the most important, namely the necessity of establishing a solid amount of postgraduate research on machines and power engineering. Until this comes about, it is true to say that some of the best minds will be lost to this field in favour of electronic engineering, and the solving of this problem is not going to be altogether easy.

A great deal of industrial development in machines has been concerned with orthodox applications of new materials with improved properties. Loosely speaking, what is required in addition now are the unorthodox applications. It is fairly apparent that, while university departments cannot proceed very far with the first line of approach, they should be able to contribute to the second, and a large amount of open ground is available here. One other branch which may be developed is the investigation of new interactions (using either magnetic or electric fields as the coupling medium) between conducting circuits by adopting different lay-outs and geometries. Electrostrictive and magnetostrictive devices also seem to offer wide possibilities for research and development.

And in addition to these research proposals, there is a large amount of development work which is highly important. Part of this is now covered by the activities of the various development laboratories attached to the larger manufacturers, but there is no reason why work on a limited scale should not proceed in the universities. Some suggestions for work of this nature are the development of static frequency-changing devices, constant-voltage constant-frequency a.c. generators having variable-speed drives, investigation of the impulse excitation of magnetic cores, the development of devices for continuously switching direct current up to, say, 100 times per second at mains voltages and with a wide range of current, and the exploration of improved methods of distributing electric stresses. There are in fact many such items, and one is always strangely perturbed to hear the view expressed that there is very little yet to be done in power engineering.

Relations with industry

The establishment in the universities of research on the above lines on a scale comparable with that in the electronic field does offer some difficulty. Not the least of the obstacles to be overcome is the grave shortage of younger members of university staffs interested in the machine and power fields. Just at a time when the situation demands men of the highest calibre with an ability for research and teaching, the supply of such men is indeed very poor. Much of the postgraduate research at the universities is conducted in the years immediately following the obtaining of a first degree, desirable though it may be to procure research men of some years' experience in industry. The supervision of inexperienced research workers is a time-consuming process, and it is difficult to see how this work can become broadened and extensive without some influx of new academic staff. This is indeed serious for, although the universities, with a proper approach to industry, could reasonably hope to draw on that field for lecturers to conduct specialist postgraduate courses on a part-time basis, the two are in competition for full-time staff, and particularly so for men who can be perceived as leaders of thought in their subject.

This leads one to consider whether industry itself has not a part to play in enlivening the machine and power field. No one will dispute the immense amount of development work which day by day is carried out in the many departments of manufacturing concerns; and the fact that much of this is relatively unspectacular compared with some recent electronic achievements in the fields of computation, radio astronomy and space research naturally does not detract from its merit. Nor would one dispute that the lively postgraduate internal

lecture courses and discussions, which some of the larger concerns have taken the trouble to develop, are of the utmost value to industry and the universities alike. More of this is undoubtedly needed. In addition one feels that greater effort should be made, through project work attached to the various industrial development departments, to enable graduates to exercise, during their training period, the intellectual power of which they (or most of them) are capable, and which has been brought to a high state of readiness by their university course.

One might also suggest that more laboratory space than at present should be set aside for work which is not immediately seen to be of primary commercial importance, and that in such laboratories the various sidelines which so often arise in the course of developing apparatus to meet specific needs can be fully gone into. One just cannot say, at the beginning, that such and such a line of investigation (if it is at all fundamental) would be fruitless. How often it is true that the main branches are disappointing but the fecundity of the offshoots exceeds expectation.

To bring about the wide growth of fruitful and lively research in machines and power engineering is not easy. It will be accelerated, however, by a realization of the problem, by discussion, and by proper relations between the universities and the colleges of advanced technology on the one hand and the various Government research establishments and industry on the other. I should not, however, presume to say how this will be achieved.

Summary

In summing up, the features of this present-day issue which now obtrude or should obtrude on our minds are as follows. Insufficient graduates, including high-quality graduates, are entering the power or machine side of electrical engineering, and the postgraduate field in particular still remains relatively static in comparison with electronic engineering. This is in part, and only in part, due to the narrowness of past courses. Infusion of a more general outlook into these courses is, therefore, necessary on this account, and on the further account of providing more fundamental scientific bases capable of supporting future advances in an expanding branch of engineering. Improvements in the machine side will become possible only by the inclusion of deeper physical studies of materials and their properties and of field and circuit phenomena, supplemented, where profitable, by general mathematical analysis.

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BRITISH RAILWAYS ELECTRIFICATION CONFERENCE

REPRESENTATIVES of over 40 different railway administrations from countries all over the world, including the United States and the Soviet Union, African, Asian and South American states, most European countries and many countries and territories in the British Commonwealth, took part in the British Railways electrification conference in London from the 3rd to 7th October 1960. The conference was organized jointly by the British Transport Commission, the British Electrical and Allied Manufacturers' Association, and the Locomotive and Allied Manufacturers' Association of Great Britain.

In opening the conference at The Institution of Civil Engineers on the 3rd October, Sir Brian Robertson, Chairman of the British Transport Commission, spoke of the conference as a landmark in British railway history. There followed the inaugural paper by Mr. S. B. Warder, Chief Electrical Engineer of the British Transport Commission, on 'Electrification in the modernization of British Railways: the choice of the 50-cycle system'. Mr. Warder concluded by saying that the overriding consideration which the conference had been convened to demonstrate was the noteworthy developments in electrical engineering which had been stimulated by a.c. traction.

In the afternoon, the Minister of Transport, Mr. Ernest Marples, opened an electrification exhibition at British Railways Battersea Wharf depot. Apart from stands of the individual manufacturers concerned, there were on display several different types of electric locomotive and motor coach. In all the locomotives, great emphasis had been placed on comfort and ease of driving and maintenance, and it was interesting to see the varying ways in which the several manufacturers had interpreted these requirements in their final designs.

On the 4th October, papers were read on the application of the 50c/s system as proved by system tests; the locomotives; the multiple-unit trains; and the power supply. Other papers relating to these subjects were presented at each session. There was an all-day visit to the Manchester–Crewe electrification scheme of the London Midland Region of British Railways on the 5th October; and on the 6th October papers were read on the overhead-line equipment; civil-engineering aspects; research for a.c. traction; signalling and telecommunication; and the interference problem. Other papers concerned with these topics were presented at the same sessions.

On the 7th October there was an all-day visit to the electrification scheme of the Eastern Region of British Railways, including the Colchester–Clacton–Walton line, which was the first line in Great Britain to be electrified on the British Railways 25kV 50c/s system.

Over 450 delegates attended the conference, including some 200 railway managers and engineers from abroad.

An interesting feature of the opening meeting was the use by delegates of transistor radio receivers which provided simultaneous translation into French, German or Spanish and also enabled the speakers to be heard at the back of the hall.

DEVELOPMENTS IN AIR TRAFFIC CONTROL

621.396.933.4

The average airline passenger is probably more concerned with the quality of the multi-course meal provided by the operator of his choice or the comfort of his reclining seat than with the intricate organization which controls the progress of his aircraft and ensures that his journey is safe and speedy. From some time before his aircraft taxies away from where he boarded it until it comes to rest at its destination, the air traffic controllers have been constantly on the watch, ready to intervene if the situation demanded some change of plan. This article highlights the present status of, and possible future developments in, air traffic control.

A symposium on data handling and display systems for air traffic control was held at Savoy Place on the 8th April 1960 (Proceedings I.E.E., 1960, 107B, Suppl. 19).

Dr. O'Kane is with Marconi's Wireless Telegraph Co.

B. J. O'KANE, PH.D., B.ENG., ASSOCIATE MEMBER

SINCE the end of the 1939–45 War, air traffic has grown apace and the control problem has become correspondingly more complex. In the areas where traffic density is greatest, for example parts of the United States and Western Europe, the task of the controllers is becoming too great for the mind to deal with unaided, and computers are being installed to assist the controllers. In this short article it is hoped to give the non-specialist some insight into the development of air traffic control up to the present day and likely trends in the future (Fig. 1).

There are several factors concerning any flight which the controller must know. Some of these factors are determined beforehand; others change during the flight, either because of the incorrect operation of the aircraft or bad weather forecasting or as a result of instructions from the controller. This information is entered on a flight progress strip which is displayed to the controller and kept up to date, normally by the controller himself. This flight progress strip is the key to the A.T.C. system (Fig. 2).

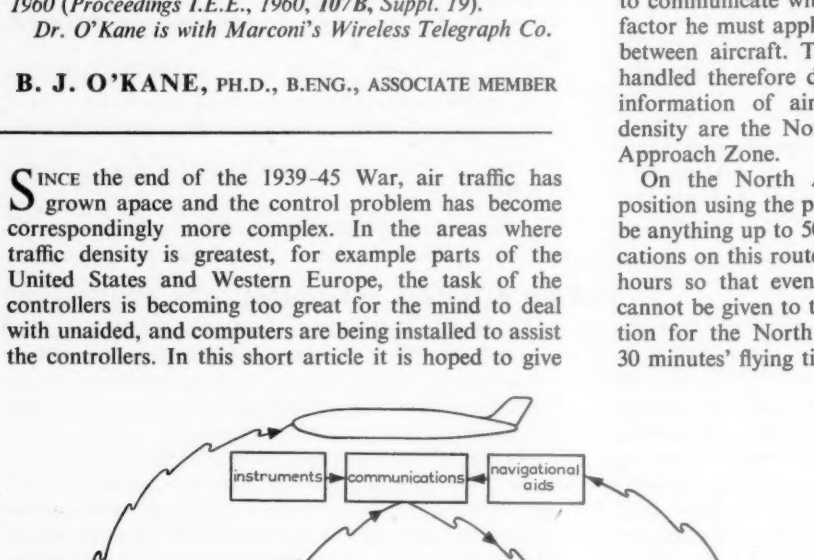
Position of aircraft

In order to keep the flight progress strips up to date, the controller must have as exact information as possible of the aircraft's present and future position in three dimensions. The less accurate this information, resulting from, for example, lack of navigational aids or inability to communicate with the aircraft, the greater the safety factor he must apply, that is, the greater the separation between aircraft. The density of traffic which can be handled therefore depends on accurate and immediate information of aircraft positions. Two extremes of density are the North Atlantic route and the London Approach Zone.

On the North Atlantic route, the estimated plan position using the present aircraft navigational aids may be anything up to 50 miles out. Furthermore, communications on this route can be completely cut off for some hours so that even this rather indeterminate position cannot be given to the controller. The minimum separation for the North Atlantic route is, in consequence, 30 minutes' flying time longitudinally and 2° of latitude laterally. Each aircraft therefore requires several thousand square miles of sky.

In contrast, in the London Approach Zone where all the aircraft can be monitored by ground radar, longitudinal separations are down to five miles, allowing a much greater traffic density with complete safety.

It is, of course, in the terminal areas that the traffic



1 *Elements of an A.T.C. system*

In the centre the controller monitors the traffic pattern and exercises his judgment if traffic conflicts are likely to arise. Routine calculations and clerical work will increasingly be performed automatically

is naturally densest, but the limitations on the North Atlantic route frequently impose operational penalties. A common example is that an aircraft cannot climb to its planned altitude, lack of precise knowledge of the position of other aircraft preventing the controller from giving the pilot permission to do so.

The routes which aircraft follow between terminals are known as airways and these canalize the controlled traffic, making the controller's task simpler and leaving the rest of the airspace free for uncontrolled flights such as military operations. Aircraft flying the airways have to carry a statutory minimum of radio equipment for communication and navigation. The controller regulates the traffic on the airway from information on the flight progress strip, monitoring being carried out by ground radar in many cases.

The controller must visualize the whole traffic pattern for which he is responsible, and, from a knowledge of arrival times at specified points, decide whether a dangerous situation can arise. If it can, he must issue instructions to one of the aircraft concerned to prevent this.

He must also consider the areas outside his own, as he must be able to accept safely aircraft into his area and pass them on to the next. It is this visualization of the situation plus the communication load which becomes increasingly onerous as the traffic builds up. Therefore the controller must be relieved of as much routine work as possible, leaving him free to exercise his judgment without being unduly stressed.

Radio aids

Before 1939 radio aids were few. The United States introduced four-course medium-frequency radio ranges around 1927 and so started the concept of airways. M.F. ground direction-finding with bearings passed by radiotelephony was used in this country, and a blind approach aid came into use before 1939. Airborne direction-finding was also used. Aircraft separations on crossing tracks were maintained by the 'quadrantal' rule, which defined the altitude levels for flights in the four sectors N–E, E–S, S–W, W–N. Fixes could be obtained when flying over beacons, or by cross-bearings from two direction-finders or radio ranges. Generally speaking, the traffic density was so low that the chances of collision were extremely remote.

The 1939–45 War saw the development of a number of airborne and ground-based systems, and the more enthusiastic saw in them the solution to the A.T.C. problem. However, it has taken many years to introduce a limited selection of the many devices which were designed for military purposes. There was a tendency to lose sight of the fact that in war an aircraft travelling between two points—if one is in enemy territory—has every man's hand against it. In peace every man is helping it on its way. The cynical sometimes detect little difference, but this is generally due to faults in organization rather than a deliberate attempt to impede.

Wartime developments which have been adopted or adapted for civil operations are primary radar (airborne and ground), secondary radar, 200 Mc/s distance-measuring equipment, v.h.f. communication and direction-finding, hyperbolic ground-based aids (either phase or pulse comparison), radio altimeters,

2 *Controllers at Southern Air Traffic Control Centre, London, showing flight progress strips*

and instrument landing system (I.L.S.). Since 1945, the v.h.f. omni-range (V.O.R.) beacon has superseded the m.f. four-course ranges. 1000 Mc/s distance-measuring equipment to supplement V.O.R. has been adopted by the International Civil Aviation Organization (I.C.A.O.), the regulating body under the United Nations.

Today, therefore, the electronic systems in use for A.T.C. are numerous, and the introduction of a new system rarely means that an old one is discarded. The radio installation in an international airliner is a far cry from that of before the war. A brief description follows of airborne and ground systems at present in use for the generation, handling and display of information for A.T.C. purposes.

Airborne and ground systems

Position information and ground speed can be derived in the aircraft, for example by means of radio aids, and the estimated time of arrival at the next reporting point can then be passed over a communication channel to the controller. This information can also be derived or checked by ground radar. Radionavigational aids vary in accuracy and also in their susceptibility to interference (man-made or natural), and furthermore they may not be fully implemented because of lack of international agreement. The most commonly used aid even today is the m.f. radio compass. The internationally standardized short-range aid is V.O.R./D.M.E., which operates in the v.h.f./u.h.f. bands, rendering it virtually immune from atmospheric interference.

Under discussion at the moment is the standardization, in place of the present D.M.E., of D.M.E.T., the distance-measuring component of Tacan, a United

States military system. The combination of V.O.R. and D.M.E.T. is known as Vortac. These latter point-source aids, or rho-theta systems, give bearing and distance to or from a beacon, and estimated times of arrival can readily be worked out. A low-frequency hyperbolic system, although liable to interference, is intrinsically more accurate than V.O.R./D.M.E., and some system of this kind is likely to be essential to allow reduced separations as traffic density increases.

The greater accuracy arises from the fact that position is measured by the phase difference between signals from pairs of stations separated by, say, 100 miles. Lines of equal phase difference are hyperbolae, and, in the coverage area where these hyperbolae intersect at angles approaching 90°, the accuracy is high. As the angle of intersection decreases, so also does the accuracy. A V.O.R. station which gives a bearing from a point suffers from siting as well as instrumental errors, and position error increases with distance from the station.

A new radio aid, security-released a few years ago, is the airborne Doppler system. This, being independent of any ground installations and working in the microwave band, does not suffer from the disadvantages of other aids. With this aid, accurate ground speed and drift angle are found directly and not derived as an average over a long period, during which they may well have changed violently. This information can be fed into a navigational computer which can indicate the distance to go and hence the estimated time of arrival, or the present position, for transmission to the controller. The system accuracy is limited by the existing heading references, but these are being improved all the time. The heading reference most commonly used is the gyromagnetic compass, but free-drift gyro references with a wander rate of one or two degrees per hour are already in service. Developments in progress promise operational accuracies of an order better than this. As it is an integrating system when a computer is used, errors will accumulate, and after a long flight it is necessary to correct the computed position by reference to some other aid.

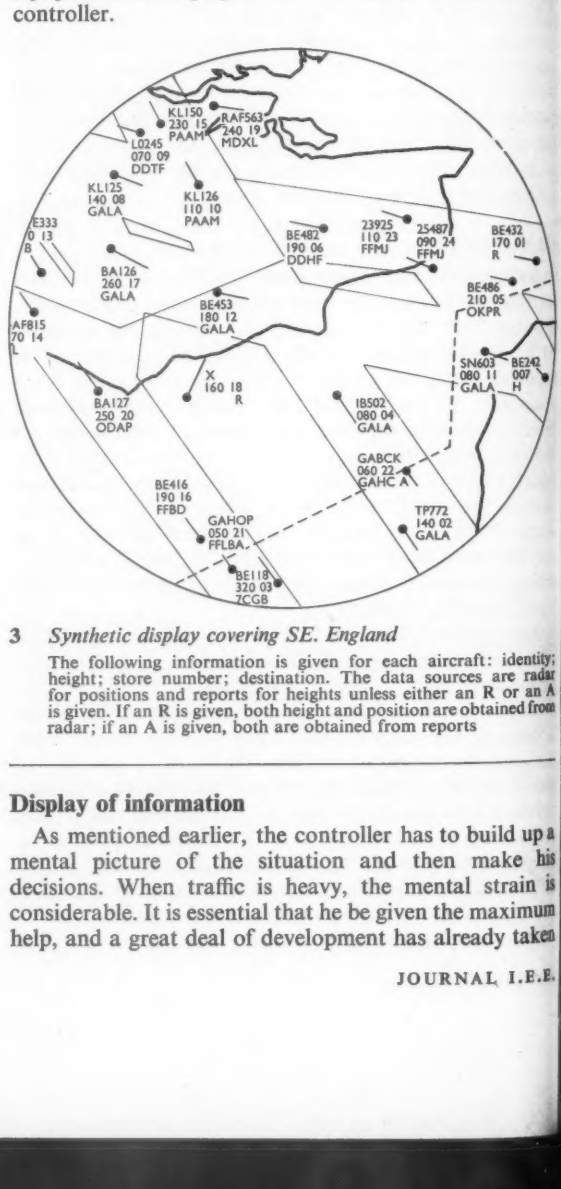
Data links

Information is at present passed to the controller by radiotelephony, over either h.f. channels for long-distance operation or v.h.f. channels for short distances. Work is going on both in the United Kingdom and in the United States on data links for both air–ground and ground–air messages. Telephony will then be used only for non-routine messages, thereby considerably relieving channel loading. A ground–air narrow-band frequency-shift v.l.f. radio teletypewriter link is already operating successfully on the North Atlantic route for transmitting weather information.

In the United States an automatic ground–air–ground communication system (A.G.A.C.S.) is undergoing experimental trials. This system, at present confined to the v.h.f. and u.h.f. communication bands, uses a binary code for predetermined messages of approximately 100 elements, the airborne equipment decoding and displaying the information to the crew. There is an automatic check on the message content, and each message is repeated—up to three times—to ensure accuracy. These repeats are, of course, liable to cause overloading of the channels.

On the ground, the controller works from his flight progress strips, which are kept up to date from information being received from all sources. In an increasing number of cases, ground radar is available for monitoring the progress of the aircraft under his control. Great strides have been made since 1945 in the design of ground radar. As well as having increased power and aerial gain, means for eliminating permanent echoes and precipitation clutter have been devised. Frequencies range from 600 Mc/s to 10 Gc/s, depending on the particular requirement. Displays have improved in brightness and definition.

Identification of a particular aircraft out of a number may be by v.h.f./d.f. or, increasingly, by transponder (secondary radar) where a coded replay from the aircraft equipment is displayed on the radar screen to the controller.



3 *Synthetic display covering SE. England*

The following information is given for each aircraft: identity; height; store number; destination. The data sources are radar for positions and reports for heights unless either an R or an A is given. If an R is given, both height and position are obtained from radar; if an A is given, both are obtained from reports

Display of information

As mentioned earlier, the controller has to build up a mental picture of the situation and then make his decisions. When traffic is heavy, the mental strain is considerable. It is essential that he be given the maximum help, and a great deal of development has already taken

place in the United Kingdom, the United States and the Netherlands. Information can be fed into a store from any number of sources—radar, aircraft, etc.—and the essentials extracted and presented to the controller on a 'synthetic' display (Fig. 3).

The term 'synthetic' is used to distinguish this type of display from the more familiar plan position indicator which presents 'raw' radar information.

This raw radar display may contain unwanted information, for example clutter from precipitation. Furthermore, the synthetic display can use a bright, short-persistence tube for viewing in high-ambient-light conditions. Such a display could indicate identity, height, speed and direction of as many aircraft as may be desired, for example those at a given altitude. In addition, the information will be stored in a form which will allow computation of future position and therefore prediction of conflicts. A bright, short-persistence display will allow this prediction to be displayed without confusing the picture.

A short-persistence display cannot be used for the raw radar, as the information rate, i.e. the rotational speed of the aerial, has to be low.

Flight progress strips may be brought up to date automatically, although there are difficulties. Information may be repeated to other controllers by closed-circuit television links. Such a system has already been demonstrated. Electromechanical indicators have been used instead of cathode-ray-tube displays. The important factor in all these proposed systems is that they are evolutionary, i.e. they are logical extensions of the present system and therefore can be introduced without dislocation.

Sequencing for landing

The operation of A.T.C. on the airways and in the terminal area has been dealt with, but of course, unless the aircraft are overflying, i.e. flying through the control area without landing, they must be properly sequenced for landing and kept at the correct separation. This separation will partly depend on the approach and landing aids available, and these at present are I.L.S. and ground-controlled approach. The latter consists of two elements, a surveillance radar for sequencing the aircraft and a precision approach radar for the final 'talk-down'. Neither of these is a 'landing' system, the last phase below about 200ft having to be carried out visually. Electronic coupling between the I.L.S. receiver and the automatic pilot improves the accuracy with which approaches can be made.

Several blind-landing systems have been developed, but none of these is likely to be used in civil operation for some years, although a partial implementation to assist the pilot to 'flare-out' the aircraft just before touch-down is expected within the next three or four years at London Airport. 'Flare-out' is the phase between the flight down the glidepath (approximately 2½° to the horizontal) and the final horizontal motion along the runway.

The sequencing of aircraft may be assisted by special displays and computation to derive the flight path necessary to ensure that aircraft are correctly separated on the final approach.

The position of aircraft on the runways and taxi tracks can be monitored by radar, in this case a short-range very-high-definition system, called in this country the airfield surface movement indicator (A.S.M.I.).

Summary

Electronics is clearly playing a great part in smoothing the way of the air traveller by helping the air traffic controller, and in the future it will be of even greater assistance. The equipment designer is always conscious of his responsibilities for safety in the air, and increased reliability in spite of increased complexity is foremost in his mind. Increased complexity inevitably means increased cost, but it is still in general a small proportion of the cost of a modern international airport.

It is hoped that this very brief survey will have given some inkling of the A.T.C. system which guides a passenger safely to his destination even though he may have seen nothing but cloud since his flight started.

Improved signalling on the District Line

LONDON Transport announce that the signalling on the District Line between Earls Court and Putney Bridge is being modernized and that the junction and point operation has been arranged to be automatically effected by programme machines.

The new signalling arrangements at Parsons Green were brought into operation for the start of traffic on the 9th October 1960, and those at Putney Bridge will follow soon.

The programme machines used are basically the same as those introduced on the Northern Line and at Watford (Metropolitan Line) in 1958, but important new features have been included in the present installation, namely:

The identification of all trains on the programme rolls is now by train number, which is punched on the roll in decimal-binary-code form. A method of permitting some flexibility between the prearranged programme and the shunting movements on the ground at Parsons Green sidings has been provided.

The signal-boxes at Parsons Green and Putney Bridge are being closed and replaced by interlocking machines of the standard London Transport type, housed in specially built relay rooms at the stations concerned. The interlocking machines are themselves controlled by programme machines housed in the same rooms.

A supervision room from which the normally automatic signalling at Parsons Green and Putney Bridge can in emergency be controlled by pushbutton operation has been built at Earls Court.

CABLEFILM 621.397.12

'Cablefilm' is the name now given to news film which has been received as a facsimile by transmission over a circuit in the transatlantic telephone cable instead of having travelled by the more orthodox air freight. The apparatus required for transmission was developed by the Engineering Division of the British Broadcasting Corporation as the outcome of a request made by B.B.C. Television News for a method of obtaining news pictures as soon as possible after the event had occurred on the far side of the Atlantic Ocean.

This article is based on a lecture entitled 'The transmission of news film over the transatlantic telephone cable' given by the authors at an Ordinary Meeting at Savoy Place on the 3rd December 1959. They are with the B.B.C.

C. B. B. WOOD

I. J. SHELLEY, ASSOCIATE MEMBER

CABLEFILM will, no doubt, eventually be superseded by live transatlantic television, but there is at present no communication circuit between Europe and North America available for the transmission of such video signals, and it is necessary to sacrifice the immediacy of a live broadcast in order that the bandwidth of the signals transmitted may be drastically reduced to suit the available circuit facilities.

Cablefilm is basically an elaboration of the well known system of photo-telegraphy, or picture facsimile, in which single still photographs are transmitted over narrow-band radio or cable links by being scanned in a manner similar to that employed in television. The scanning process in a standard picture-facsimile system is carried out so slowly that the signal fluctuations representing changes of tone in the picture occur at frequencies not exceeding a few hundred cycles per second.

The signal fluctuations are translated into a form suitable for transmission over the circuit, and at the receiving point a machine, scanning in synchronism with the sender, records the signals as shades of light and dark upon a sensitized paper and so creates a facsimile of the original picture. The whole process takes some 10 or 15 minutes, depending on the degree of detail which is required in the received image and on the available bandwidth in the communication circuit used.

If it is desired, as in cablefilm, that the pictures transmitted shall portray movement in the scene, a succession of still pictures must be transmitted, eventually to be presented to the viewer at the same rate at which they recorded the original scene, as in cinematography.

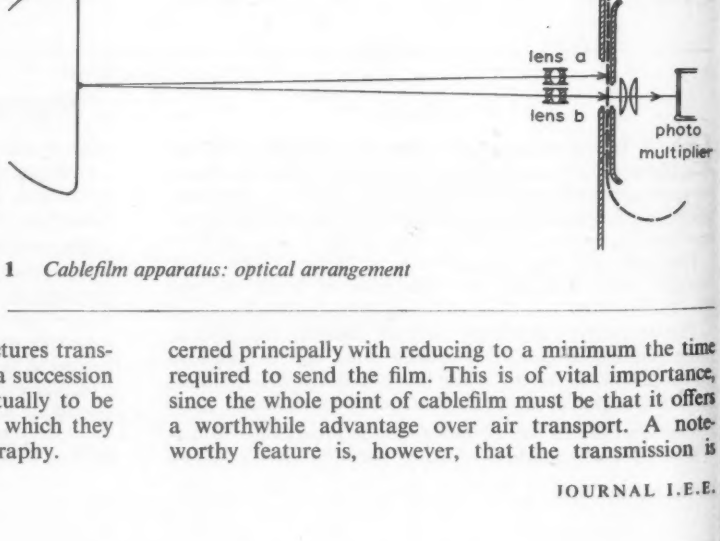
The quickest method

At present, the quickest method of providing viewers in Europe with short news films of an event in North America (or vice versa) is, in the simplest terms:

1. To film the event
2. To transmit over the transatlantic telephone cable, as picture signals, each individual frame of the film. By accepting a very much lower standard of resolution than that offered by the photo-telegraphy service, and because circuit arrangements in the transatlantic telephone cable permit nearly ten times the bandwidth used in normal photo-telegraphy, the time required to send one frame of film can be made a small fraction of the 10 or 15 minutes already mentioned. The transmission time for a cablefilm is nevertheless 100 times the normal running time of the film
3. To record on film, at the receiving point, incoming picture signals as individual frames making up a facsimile of the original film
4. To replay the reconstituted film, at its normal speed, over the local television system.

In practice, the event is rarely filmed directly, but a film telerecording is made from the local television broadcast of the event. The telerecording is edited to a suitably short length, usually about one minute of programme time, and the film is then put into the cablefilm apparatus.

The engineering problems encountered in designing a practical system of cablefilm transmission were concerned principally with reducing to a minimum the time required to send the film. This is of vital importance, since the whole point of cablefilm must be that it offers a worthwhile advantage over air transport. A noteworthy feature is, however, that the transmission is



1 *Cablefilm apparatus: optical arrangement*

from one television news centre directly to another, thereby avoiding all the delays in freight offices, airports and customs which may often amount to a substantial proportion of the total transit time.

There are two lines of attack in achieving the maximum speed of sending films:

1. To design scanning apparatus, and adopt standards (i.e. line scan frequency and number of lines per frame etc.) which will give acceptable picture quality but nevertheless considerably reduce the amount of information which must be transmitted
2. To derive from the existing circuit facilities in the transatlantic telephone cable a circuit of the greatest possible bandwidth commensurate with acceptable transmission characteristics.

Programme circuits

The transatlantic telephone cable is a joint undertaking of the American Telephone and Telegraph Company, the British Post Office, and the Canadian Overseas Telecommunications Corporation. The cablefilm signals are transmitted over the cable on a circuit which is normally used for sound-broadcast transmissions. Three such circuits, known as 'programme circuits', are provided in each direction in the cable, two between London and New York and one between London and Montreal. Each programme circuit has a nominal frequency band of 50c/s–6·4kc/s and when required is derived by combining the bandwidths normally used for two ordinary telephone channels.

To investigate the possibility of transmitting cablefilm signals over a programme circuit in the transatlantic telephone cable, tests were carried out early in 1958 over a loop circuit between London and New York. The results obtained at this stage led to the conclusion that there was every likelihood of deriving a satisfactory cablefilm circuit having a video bandwidth of about 4·5kc/s.

Scanning standards

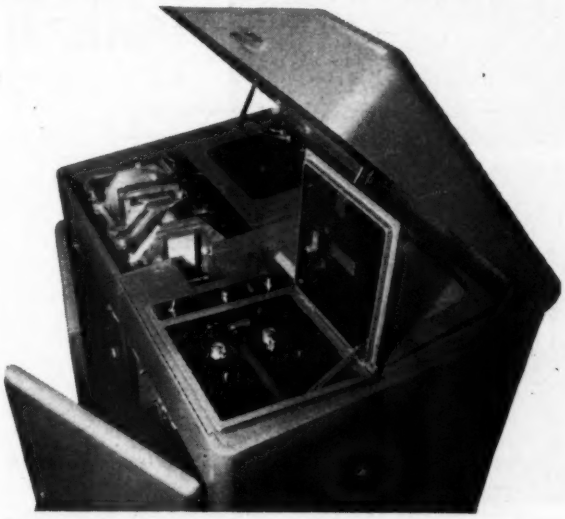
The maximum video frequency having been determined, the next decision necessary was where to strike a compromise between picture quality and the speed of sending. Clearly, the British 405-line standard of picture quality could not be retained, for the scanning speed would have to be reduced in the ratio of 4·5kc/s to 3Mc/s, i.e. about 660 times, meaning that a one-minute news film would take 11 hours of sending time. Fortunately, it was possible to synthesize, photographically, some of the proposed reductions in picture quality to assess the probable performance of the system in advance.

Film used for news purposes in this country, and in North America, is almost invariably 16mm gauge and it was therefore an obvious choice for the cablefilm system.

Experiments and subjective tests with suppressed-frame telerecordings and 16mm film led to the adoption of picture standards as follows:

1. 200 scanning lines per frame
2. 360 picture elements to each line (equivalent to 1·75Mc/s bandwidth on normal 405-line standards).

In these conditions, with a maximum permissible video frequency of 4·5kc/s, the line scanning frequency is limited to 25c/s, and with 200 lines to the picture one complete frame is transmitted in eight seconds.



2 *Scanning console*

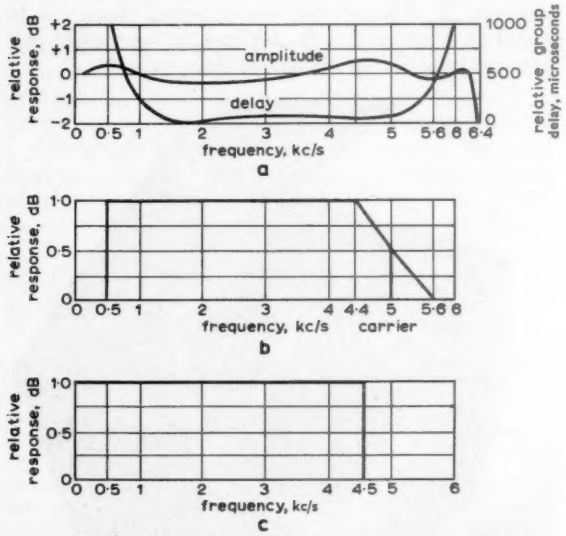
A further 2 : 1 reduction in sending time was achieved by transmitting only alternate frames of the original film. The film at the receiving end is restored to the correct length simply by recording each incoming frame in duplicate, simultaneously in adjacent film frames. Thus if the frames of the original film are numbered 1, 2, 3, 4, 5, 6 . . . etc., the received film comprises frames 1, 1, 3, 3, 5, 5 . . . and so on. This economy occasionally makes motion in the picture appear jerky, but it is generally acceptable. When sending alternate frames of the original film at the rate of one every eight seconds, the transmission takes 100 times the normal running time of the film and the one-minute news item takes 1h 40min to send.

Film-scanning equipment

When sending, the arrangement of the apparatus is as shown diagrammatically in Fig. 1 and is similar to that of the ordinary flying-spot telecine machine. The camera carries the processed film material which is to be transmitted, and light from the flying-spot scanning tube, imaged by lens B, scans the film and becomes modulated as it passes through to be collected and transduced into electrical signals in the photomultiplier.

The image produced by lens A has no useful function in this case.

In the receiving condition, the incoming signals modulate the brightness of the scanning spot and the camera is loaded with unexposed film. Lenses A and B are now both operative and simultaneously record the incoming picture in duplicate, in adjacent film frames.



3 *Transatlantic-telephone-cable carrier and video characteristics*

a London–New York circuit: characteristics after equalization
b Characteristic of vestigial-sideband carrier channel
c Characteristic of video channel

A negative or a positive film may be placed in the apparatus at the sending end, but the facsimile is always produced as a positive by photographing a negative picture on the cathode-ray tube. Where the original material is a positive film, the picture signals have to be processed electrically to make them negative in form before transmission. Incoming or outgoing pictures are displayed for monitoring purposes on the 14in. rectangular long-persistence screen of a cathode-ray tube which can be seen alongside the control panel of the scanning console in Fig. 2.

The accompanying sound track is usually sent separately at normal speed directly over the cable circuit during the period when the received film is being developed. The sound is recorded on 16mm magnetic film, which, after synchronization with the pictures, can be broadcast in the usual manner.

Transmission equipment

The cablefilm signal includes extremely-low-frequency components, below 0·1c/s; the direct transmission of such signals over a programme circuit is clearly quite impracticable and the use of carrier transmission is essential.

The requirements for the transmission of a picture waveform are, in many ways, more stringent than those for either speech or music. The video waveform consists of a large number of individual signal-frequency components, and ideally these must be transmitted over the circuit without disturbing either their relative amplitudes or phases. This means that the transmission circuit must have a flat frequency response and that the various frequency components of the signal must all be propagated with the same velocity, i.e. the group delay must be constant over the frequency range of the transmitted signal.

The Post Office Submarine Cable Group supplied measurements of the group-delay characteristic of a programme circuit, and a 4-section fixed equalizer and a 6-section variable equalizer were designed which together reduced the delay distortion over the frequency range 1·2–5·4kc/s from 500 microsec to less than 100 microsec (Fig. 3a).

Modulation system

Undoubtedly, the simplest method of transmitting the video signal over the programme circuit is to use double-sideband amplitude modulation, but this requires a bandwidth of twice the highest video frequency. In a vestigial-sideband system, one complete sideband of the modulated carrier is transmitted together with a vestige of the other, and the over-all bandwidth required is then only a fraction more than for the original video signal, and this type of transmission was chosen.

Video signals up to 4·5kc/s modulate a 5kc/s carrier, and the signal transmitted over the programme circuit lies in the frequency range 0·5–5·6kc/s (Fig. 3b and Fig. 3c). The frequency band of the modulated carrier overlaps the frequency band of the video signal, and special precautions were taken when designing the modulator and demodulator to avoid interference between the modulated carrier and the video signal. The modulator differs from those in common use for telephony in having the carrier and signal inputs interchanged, thus enabling the video signal to be directly coupled, an essential requirement with the very low field frequency used in this system.

The programme-circuit volume range compressors and expanders, which are normally used to improve the signal/noise separation for broadcast transmissions, have to be removed when the circuit is used for cablefilm transmission. To obtain a satisfactory signal/noise ratio over the circuit in this condition, a special form of amplitude modulation has been used in which the modulation factor exceeds unity. It is then more convenient to define the modulation depth in terms of an excess-carrier ratio, this being the ratio of peak carrier amplitude to peak-to-peak amplitude of the excursion of the carrier due to modulation.

For a given transmitted signal level, an excess-carrier ratio less than unity can be used with advantage to improve the over-all signal/noise ratio, but with the complication that the video signal can no longer be

recovered with a conventional envelope detector and synchronous demodulation is necessary. This requires a regenerated carrier at the receiving terminal which must be synchronous in phase and frequency with the in-phase carrier component of the received signal.

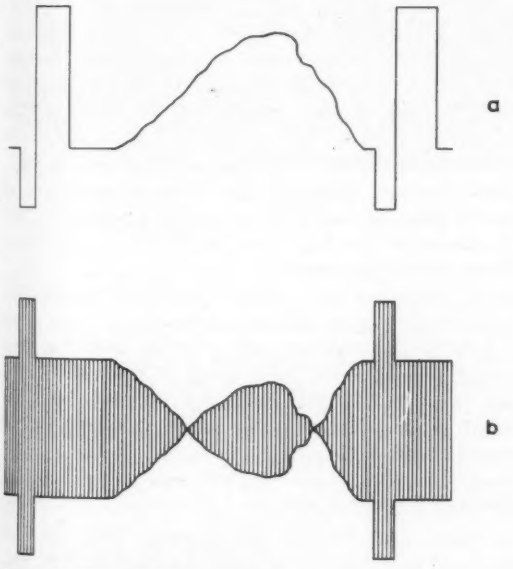
Using negative modulation and an excess-carrier ratio of 0·65 (Fig. 4), the presynchronizing pulses in the modulated carrier envelope have a larger peak-to-peak excursion than the picture information, thus permitting the pulses to be detected with an envelope detector. These pulses then operate a sampling device during the period of each line-synchronizing signal, and the bursts of carrier which are obtained are used to lock the local oscillator required for synchronous demodulation.

Compared with unity excess-carrier ratio, this arrangement operated over a programme circuit allows an over-all improvement of 6dB in the signal/noise ratio.

Test facilities

The test signals incorporated in the system follow those now widely adopted for television transmission testing. The method of displaying the time response of the system under test to a specified sine-squared pulse-and-bar waveform allows both the equipment and the trans-atlantic programme circuit to be set up in the minimum of time. The test waveform is generated as a video signal, and, although the variable amplitude and delay equalizers operate at carrier frequencies, they are adjusted to provide the best over-all results by observing the received video signal on a waveform monitor.

The programme circuits have given remarkably consistent results, and their characteristics have remained so stable that only quite minor adjustments to the equalization have been found necessary.

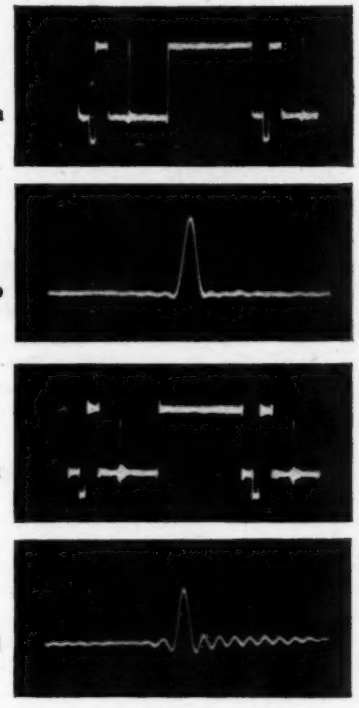


4 *Cablefilm modulation system*

a Video waveform
b Modulated carrier: modulation factor 3·3, excess-carrier ratio 0·65, negative modulation

Operations between London and Montreal

In February 1959 it was decided that the system should be used during the Queen's visit to Canada in June, as this important occasion would provide a unique opportunity for its inauguration. As the transmission equipment had been specifically designed for operation on the London–New York programme circuits, it had to be established that it would give a satisfactory performance when used on the London–Montreal circuit. A test was made on the 24th March 1959 over the programme-circuit loop to Montreal, and the characteristics were very similar to those of the New York circuit.



5 *Test waveforms received at Alexandra Palace after transmission from Montreal*

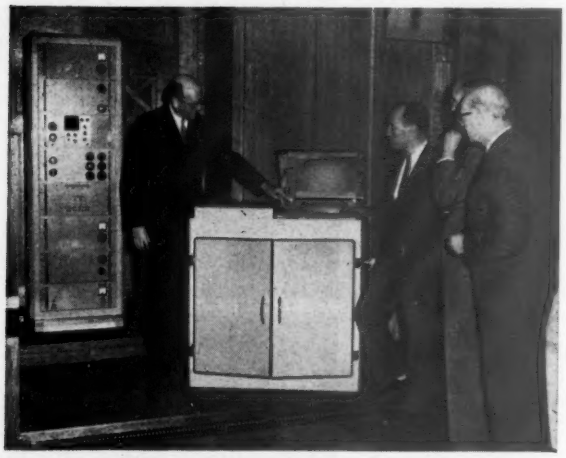
a 2T pulse-and-bar waveform
b 2T pulse
c 1T pulse-and-bar waveform
d 1T pulse

Using fully engineered equipment, the first test carried out across the Atlantic over a single circuit took place on the 28th May 1959 between Alexandra Palace and Radio Canada, in Montreal. Pulse-and-bar test waveforms received at Alexandra Palace after transmission from Montreal are shown in Fig. 5.

On the 18th June 1959, film of the Queen's departure for the tour of Canada was seen by viewers on both the Canadian and United States television networks several

hours before Her Majesty arrived at St. John's, Newfoundland. Later in the day, corresponding film of the Royal party's arrival was shown in Britain.

On the 27th June 1959, a short film of the official opening of the Moses Saunders Power Dam was seen by British television viewers only 45 minutes after Her Majesty had performed the opening ceremony.



6 *Mr. Wood explains the mechanism of the film scanner in the Lecture Theatre at Savoy Place*
The transmission equipment can be seen on the left

During the Queen's visit to Canada in June–July 1959, there were 12 transmissions from Montreal to London, and a similar number in the reverse direction for President Eisenhower's visit to Europe in September. Cablefilm has been used on more than 50 occasions of international importance, including Mr. Khrushchev's tour of America, President Eisenhower's tour of the Far East, the wedding of H.R.H. The Princess Margaret, and the Summit Conference in Paris.

A view of the apparatus used is shown in Fig. 6.

Summary

For short news items, cablefilm, operating over a circuit in the transatlantic telephone cable, provides a fast and reliable method of transmitting film across the Atlantic. Although the cost of operating over a programme circuit is about £200 for a one-minute film, this compares favourably with the cost of news film from other sources.

Cablefilm has the advantage of operating directly between television news centres, and in many cases it is the only means of providing viewers in Britain with 'same day' coverage of events in the North American continent.

THE INCORPORATED BENEVOLENT FUND: ANNUAL REPORT

THE Report of the Court of Governors of the Incorporated Benevolent Fund was presented at the Annual General Meeting of the members of the fund on the 26th October 1960.

The report with the accounts was circulated with the September 1960 *Journal*.

The total capital of the fund stood at £169703 on the 30th June 1960.

Subscriptions and donations during the year showed a continued increase from £16110 (in 1959) to £18373, largely attributable to the President's appeal circulated with the annual-subscription notices in January 1960. This appeal, and other commendable efforts in the local Centres, in addition to producing increased annual subscriptions, resulted in 288 new deeds of covenant.

In the section of the report showing the amounts raised by local Centres by social functions and special collections, the total of such amounts received from the North Midland Centre was given incorrectly, and should be £364.

The cost of grants plus management and maintenance charges was £14620, and, although this was rather less than the sum received from subscriptions and donations, it was important that income be conserved to meet an expected increase in the number of beneficiaries needing assistance.

Grants were made to 106 beneficiaries and 67 dependants at a cost of £10461.

Eight legacies were received, amounting to £5286. Further royalties accrued on a book.

The fund now has six beneficiaries resident in the Crossways Trust houses at West Worthing, Brighton and St. Leonards-on-Sea. All the beneficiaries are in the active category but require accommodation where meals and some attention are provided.

Refund of income-tax. £1970 was recovered from the Income-Tax Commissioners owing to the kindness of members who subscribed by covenant. A further £5000 could be saved if all subscribers of over 10s. per annum would use the covenant to subscribe for seven years, a procedure which involves no other obligation.

Local Honorary Treasurers. The triennial conference of Local Honorary Treasurers, held this year, again emphasized the invaluable service they render in interviewing applicants and investigating their needs.

Homes Fund. The total amount received in subscriptions and donations from the inception of the Homes Fund to the 30th June 1960 was £47440, and a further £173 has been recovered in income-tax under deeds of covenant. All the houses on 'The Chesters' estate are occupied, and the members of the little community express gratitude for the amenities provided.

Wilde Fund. Grants totalling £92 were made from the Wilde Fund during the year.

Lord Hirst Fund. On the 31st December 1959, the Lord Hirst Fund comprised investments totalling £15882 15s., which produce an annual income of about £645. The uninvested balance of the income account was £619 19s. Grants amounting to £250 were made from this fund during the year.

Reliability of electronic equipment

THE reliability of electronic equipment is a controversial topic, and in the United States is the subject of regular annual conferences. In response to a suggestion by the Electronic Engineering Association, The Institution organized a one-day symposium on the 18th May 1960 to test the British market for such affairs, with a view to possible larger conferences if there seemed to be a demand for them. Events proved that the demand was unmistakable: over 900 people registered for the symposium, which filled the Great Hall of The Institution of Civil Engineers in Great George Street, London, and overflowed into another hall.

Mr. M. J. L. Pulling, the then Chairman of the Electronics and Communications Section, opening the symposium on the 18th May 1960

On his immediate left is Mr. L. I. Farren, chairman of the first session, and on his far left Mr. R. Brewer

Formal papers to initiate the discussions could have been obtained, if at all, only with delay; so their place was taken by 31 short contributions from hurriedly invited authors, which were circulated beforehand and introduced on the day by rapporteurs. These authors, who were allowed only a few weeks in which to produce their contributions, certainly earned the gratitude of those who attended the symposium.

Three discussions on one subject

Mr. M. J. L. Pulling, Chairman of the Electronics and Communications Section, presided for the first half-hour, during which Mr. R. Brewer gave an excellent introductory survey.

For the rest of the morning, under the chairmanship of Mr. L. I. Farren, the subject was 'Users' requirements and problems'. Mr. R. J. Halsey, as rapporteur, summarized the written contributions. They included one in which Messrs. R. Brewer, J. A. Lawrence and F. J. M. Laver, as joint authors forcibly yoked by the organizers, had tried to standardize the definitions of various relevant terms. Their problem was to find common usages for designers of computers, telephone exchanges, guided missiles, and industrial control systems; they had partially succeeded, but they were pioneers ahead of their time; perhaps the contributors to some future symposium will take more notice of their efforts.

The discussion was lively; 13 speakers took part, and some of the authors replied, making a full morning's programme. It is difficult to summarize the discussion, which certainly revealed widely different approaches.

The remaining sessions were on similar lines. They were intended to present the designer's point of view: design of complete systems in the afternoon, and of component parts in the evening. The rapporteurs were Mr. L. Knight and Mr. G. W. A. Dummer; the respective chairmen Mr. E. P. Fairbairn and Mr. C. G. Garton.

It must be admitted that the two discussions were not detectably different in scope, nor did they differ much from that of the morning. Points which emerged were that the failure rates of components are nowadays of the order of 0·01–0·1% per 1000 hours, although this may not be the best way to express them; that failure rates as low as this can be measured only by special care in the organization of laboratory tests and in the reporting of faults occurring in service; but that the consequent failure rate for complete systems is not usually satisfactory, and most users would pay more for better reliability if it could be guaranteed. A controversial point was the possible need for specialist 'reliability engineers'.

Was it what we needed?

In spite of the apparent success of this symposium, it was open to some criticism, which is offered here in the hope that it will produce written support or rebuttal as a guide for the future.

Only one-third of the written contributions quoted numerical data on performance, but without such data there is only opinion, which may be wrong. (One of the written contributions, for example, gave the author's opinion that resistors would be more reliable if derated; but other people's test results show that, except in dry atmospheres, this would increase, not reduce, failures.)

The subdivision of the subject for the three sessions was apparently not acceptable, and some other way will have to be found for any future symposium, to prevent the discussion from ranging uncontrolled over the whole field. If—as the present writer suspects—the most useful and pertinent discussions would be on such limited topics as the reliability of valves, or of carbon resistors, or of paper capacitors, and so on, then the subject would be handed back to the designers and users of particular components, and reliability as a separate entity for study would not exist.

A. C. LYNCH

Improved dielectrics by means of high-energy radiation

621.315.61:621.384.62

Ionizing radiations can be utilized in the manufacture or modification of compounds for use as electrical insulation. Several examples of improved dielectrics produced by means of 4 MeV electrons are given, and the application of high-energy irradiation as an advantageous post-treatment for certain existing insulators, manufactured from organic or related compounds, is outlined.

This article is in certain respects a sequel to an earlier article entitled 'New industrial insulating materials' by W. P. Baker and F. S. Edwards (Journal I.E.E., 1956, 2, p. 14).

The author is with Associated Electrical Industries (Manchester) Ltd.

F. B. WADDINGTON, B.SC.

THE need in the electrical industry for improved organic insulation is a spur to the examination of new methods for producing or modifying suitable materials. One possible method, still in an early state of development, employs ionizing radiations by means of which chemical reactions can be initiated and the structure of compounds altered.

Radiation-induced chemical changes in organic or related materials have been known for over a century. The highly efficient photosynthesis of carbohydrates in plant life is a classic example; the formation of polymeric solids from gases or liquids exposed to electrical discharges and the hardening of rubber by high-energy electrons are also well known.

However, commercial applications of such reactions have been very much restricted by the limited power or penetration of the radiation from available sources, and it is only comparatively recently, with the advent of powerful sources of ionizing radiations such as nuclear reactors, artificial isotopes or particle-accelerating machines, that it has become possible to induce chemical changes on a scale which may prove to be commercially worth while.

Mechanism of irradiation

At a risk of oversimplification, the mechanism by which ionizing radiations induce chemical changes in organic materials may be considered simply as an extension of the mechanism whereby ordinary light promotes such changes. All radiations possessing energy greater than that of a chemical covalent bond (i.e. of the order of 3 eV) can initiate the breakage of such a bond.

Quanta of radiation in the near-ultraviolet range have just about this energy; their immediate effect is to raise electrons to excited states, i.e. to orbits of higher energy; the subsequent redistribution of this energy within a molecule containing an excited electron may result in the breaking of a chemical bond. Radiation of higher energy, above about 10 eV, is capable of ejecting electrons entirely from their parent atoms, leaving ionized atoms which may react chemically in this form but are more likely to recombine with other electrons to form excited molecules whose excess energy may be used up in breaking a bond.

If the energy of the radiation is much higher still, each quantum will, by a variety of processes, produce a large number of excited and ejected electrons with subsequent scission of chemical bonds; thus a quantum of X-radiation of energy 1 MeV, or an electron accelerated to a similar energy, may cause the rupture of, say, 10000 chemical bonds. This is in marked contrast to a quantum of ultraviolet radiation, which rarely promotes more than one or two bond ruptures. It is the ensuing reactions between these broken bonds, produced throughout a compound or mixture of compounds, which can result in new products.

Conventional methods

The inducement of chemical changes in organic materials by conventional methods in certain respects follows a similar pattern; bonds between atoms must first be broken so that the molecular fragment may

a b

1 *Irradiation grafting of Perspex to p.t.f.e.*

reform in another manner or interact with other molecules to give new products. Conventional methods of inducing such changes involve the application of energy in the form of heat or pressure or as highly reactive initiator compounds or catalysts.

The advantages of radiation-induced reactions are that bonds are broken without the necessity of distributing heat uniformly throughout a material or of admixing or contacting the material with a chemical initiator compound or catalysts. Furthermore, with a suitable choice of the type of radiation and of its energy, reactions may readily be initiated throughout considerable thicknesses of material, and in certain cases reactions may be completed in a very short space of time.

PRODUCTION OF SOLID DIELECTRICS BY IRRADIATION POLYMERIZATION

Radiation can initiate the free-radical polymerization of organic materials containing unsaturated bonds, such as ethylene, acetylene, perfluoro-olefines, and linseed oil. Polymerization of dimethylsiloxane or *iso*butene, which appears to be dependent on an ionic mechanism, can also be initiated; and certain solid-state polymerizations can be induced, such as the polymerization of acrylamide and vinyl stearate.

Though all of these polymerizations, excepting the two last mentioned, can already be efficiently achieved by conventional methods using combinations of pressure, heat and catalyst, irradiation has the advantage that no heating need be involved; the complete absence of residues of any catalyst in the resulting polymer can also be an important advantage where low dielectric loss or high electric strength is required.

Irradiation encapsulation

The coating or encapsulation of electrical components with organic polymeric materials is increasing. The polymerization of a liquid or semi-liquid material to a solid *in situ* around the components to be insulated, using conventional methods, can have the major disadvantage that electrical components containing thermally unstable materials, such as thermoplastic insulation (polythene or waxes) or heat-sensitive devices (transistors or capacitors), cannot readily be encapsulated by materials requiring heating.

Using irradiation polymerization, thermally sensitive components may be encapsulated, and a further advantage is that the electrical properties of the resultant solid encapsulation may be no worse than those of the pure base material, which, in the case of styrene or siloxane for example, can be exceptionally good. Irradiation encapsulation may present its own problems, in that certain components may be sensitive to high-energy radiation, but this can be overcome to a certain extent by limiting the penetration of the radiation so that it is largely absorbed in the insulation being polymerized.

It has been found that a large number of the compounds used in conventional methods of encapsulation can be successfully polymerized by irradiation; vinyl polymers in general require a dose in the region of 5–50 Mrad, and polyesters based on styrene or methyl methacrylate in conjunction with glycol esters require only 1–5 Mrad. However, it must be stressed that either the irradiation polymerization should be arranged to take place slowly or some form of efficient cooling should be employed to remove the heat generated in exothermic polymerization reactions.

2 *Irradiation encapsulation in silicone dielectric*
Over-all length 10 in.

As an offshoot of this irradiation polymerization, it is interesting to note that certain partially polymerized materials which contain an appreciable proportion of the monomeric compound are flexible and tough and have low softening temperatures. Such polymers could be employed for the rapid manufacture of insulator components which can be readily moulded, extruded or machined without the inducement of strain, and which on subsequent treatment by irradiation to complete the polymerization produce rigid and more heat-resistant, but brittle, solids. Polystyrene and Perspex are two materials inherently suitable for such treatment.

Absolute adhesion by graft polymerization

The irradiation polymerization of a liquid or gas to form a solid dielectric can be so arranged as to take place on the surface of a solid material of different composition; in these conditions, bonds broken by irradiation on the surface of the solid material can act as centres for initiating the growth of the new polymer. In this way the new dielectric is grafted onto the surface of the existing solid and adheres to it by primary valence bonds, i.e. the bond is as strong as any in the material itself. This is therefore a method of completely uniting two materials, even chemically incompatible materials, and is consequently an example of absolute adhesion.

Fig. 1 illustrates the bonding of two materials, polytetrafluoroethylene (p.t.f.e.) and Perspex, which are extremely difficult to bond by conventional methods; a layer of Perspex 1 or 2 mils thick was first grafted onto the surface of the p.t.f.e. by irradiating the p.t.f.e. in the absence of oxygen and while immersed in carefully purified liquid monomeric methyl methacrylate. Exposure to a small dose (2 Mrad) of 4 MeV electrons achieved the desired degree of grafting while being insufficient to affect the p.t.f.e. appreciably. The grafted surface of the p.t.f.e. was then affixed to the Perspex sheet with a conventional Perspex–Perspex adhesive (Fig. 1a).

It can be seen from Fig. 1b that, on attempting to break the p.t.f.e.–Perspex bond by applying a shearing force to the p.t.f.e. block, the fracture occurred in the p.t.f.e. in preference to the irradiation-grafted bond.

MODIFICATION OF DIELECTRICS

The conversion of a material from a mouldable, fusible or soluble state into a more permanent state in which it is insoluble, infusible and form-stable is known variously as curing, cross-linking, vulcanizing thermo-setting or drying and can apply to plastics, resins, rubbers and varnishes. Such materials are organic polymers, and the change of state results from the permanent interconnecting of chain-like polymeric molecules into a three-dimensional lattice structure by means of chemical bonds. This cross-linking, usually achieved by heating, catalysis, or prolonged exposure to the atmosphere, can, with certain materials, be induced by irradiation, thus avoiding impairment of electrical properties by catalyst residues or by thermal degradation.

Elastomers

Certain plastic putty-like compounds may be converted by irradiation cross-linking into form-stable rubber-like resilient materials which are insoluble and infusible.

Fig. 2 shows an electrical component which consists of a single turn of 0·25in.-diameter copper conductor required to withstand 25kV in an 'ampere-turn' dielectric-loss-measuring bridge. This component was insulated by means of an irradiation-cured silicone rubber; the base compound was a high-molecular-weight polydimethylsiloxane which, being a putty-like gum, was readily moulded around the copper conductor, which was held in a suitable Bakelite casing as shown. The silicone was subsequently cross-linked to a form-stable rubber by irradiating the whole component to a dose of 5 Mrad with 4 MeV electrons.

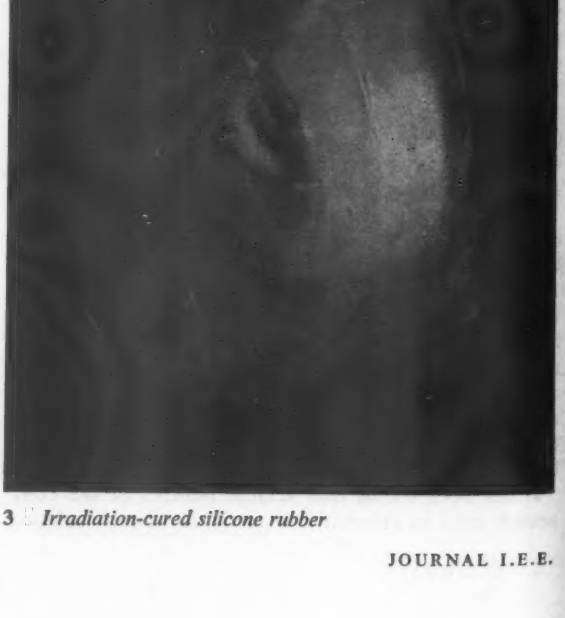
The complete absence of additives in this material resulted in the finished product being completely transparent (see Fig. 2), which enabled a thorough visual inspection of the insulation to be made for voids or other likely sources of fault.

In addition to a high electric strength and low loss tangent, this irradiated silicone rubber possesses a low Young's modulus; it therefore proved to be an ideal material for coating electrodes used for measuring the dielectric properties of thin films having surface irregularities. For this purpose, a rubber-like material was required with a negligible loss tangent which would act as a soft cushion and so take up surface irregularities during clamping of film specimens in a special electrode system.

It was found that this silicone could be rapidly cured by irradiation (i.e. cross-linked to form a resilient rubber) *in situ* on a metal surface (which was in this case a gold-plated brass electrode) to give a fair degree of adhesion. This technique could very well be employed to coat heat-sensitive materials with this silicone dielectric.

Advantages of irradiation cross-linking

Another application for the irradiation cross-linking of polysiloxane is illustrated in Fig. 3. In this case, a putty-like compound was formulated from a phenylmethylsiloxane polymer and a dry silica filler; this



3 *Irradiation-cured silicone rubber*

material could be readily moulded by hand around an electrical component as shown. The subsequent exposure to high-energy radiation produced a tough heat-resistant rubber coating having probably the best electrical properties obtainable for a filled silicone rubber. One of the main advantages of irradiation cross-linking is the rapidity of the process, which could very well be completed in a few seconds, but in this case for convenience occupied about 15 minutes.

A further advantage of irradiation cross-linking is that a large number of cross-links can readily be introduced, and this has found an application in the curing of a silicone rubber used to impregnate glass cloth, where resistance to hot solvents, which is proportional to cross-linking density, was of prime importance.

A large number of other elastomers may be cross-linked by irradiation, including acrylonitrile, butadiene, natural rubber and Neoprene. The resulting products can have slightly improved resistance to ageing and wear.

Thermoplastics

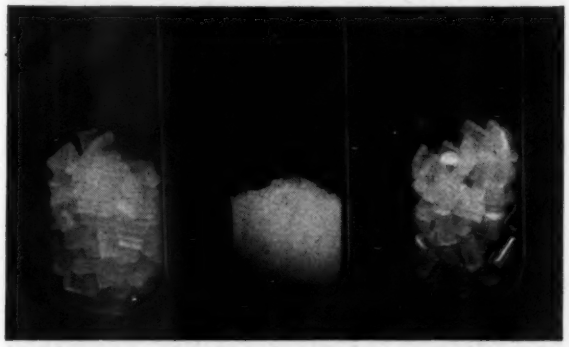
Semi-rigid or rigid thermoplastic polymers are another class of materials some members of which can be substantially improved by irradiation. These materials, which may be readily moulded, extruded or vacuum-formed, have a major disadvantage in that accidental exposure of the finished product to heat or to certain organic liquids causes them to melt or dissolve, which, in the case of an electrical insulator, could well lead to disastrous results. Irradiation of certain of these materials in the form of finished components can initiate cross-linking, resulting in an infusible and insoluble product.

The irradiation cross-linking of polythene for this purpose is now well known, and this process is increasingly employed for cables, lapping tape, valve sockets and other small components. The beneficial effect of irradiation on other thermoplastics is not so widely known. Fig. 4 shows the effect of irradiation on a polyurethane; it can be seen that, whereas polyurethane chips (Fig. 4a), after exposure to a temperature of 250°C, melt to a liquid (Fig. 4b), the same material after irradiation to a dose of 200 Mrad with 4 MeV electrons no longer melts on exposure to 250°C (Fig. 4c) and is form-stable.

Other thermoplastics which can be improved in this manner by a similar dose of high-energy radiation are high-impact polystyrene, nylon, polypropylene, and polyvinyl chloride.

However, unlike the cross-linking of elastomers and polythenes, which require doses of radiation varying between 5 and 50 Mrad, the above thermoplastics require the much more substantial, and therefore more costly, dose of the order of 100–200 Mrad. Albeit, the cost may not be prohibitive when the component is small and large numbers can be irradiated at one time.

In general, one of the major advantages of the irradiation treatment of rubbers and thermoplastics is that, since the process is quick and does not involve the addition of chemicals or the application of heat, it could be a valuable post-treatment for insulation already moulded, extruded or machined and which is found subsequently to be substandard, or that is inadvertently required to withstand more stringent conditions than those for which it was originally designed.



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4 *Improvement of polyurethane*

CONTROLLED DECOMPOSITION OF MATERIALS

In contrast to the previous examples, where use is made of the synthesizing property of high-energy radiation, irradiation can also initiate the scission of molecules into smaller fragments. This occurs when, on breaking a chemical bond by irradiation, there is no alternative arrangement by which the fragments can readily join together to form structures of increased size, and the recombination of the disrupted molecule is hindered by its inherent structure (i.e. by bulky attached atoms or groups) or the products of the scission are so mobile as to be unlikely to recombine. In such cases, some molecules remain permanently broken.

Polymeric dielectrics which can exhibit this phenomenon of scission on irradiation include Perspex, cellulosics, p.t.f.e., polymonochlorotrifluoroethylene and poly*iso*butylene; as the process is progressive and controllable, irradiation could be utilized to reduce the average size of the molecules of such polymers and so control such properties as melt viscosity and solubility. The former could prove useful in the manufacture of moulded insulators, and the latter in the production of varnishes or other coating compositions which have to be dissolved at one stage in a solvent.

Foaming by irradiation

A further application for irradiation scission arose from the discovery that certain small unstable organic molecules decomposed rapidly on irradiation to give considerable quantities of gaseous decomposition products; this gaseous evolution can be utilized to expand certain polymeric materials into the form of a foam.

Foamed dielectrics can be used to encapsulate stress-sensitive components or to fill voids.

Conventional methods of foaming have the disadvantage that the application of heat is usually required to initiate foaming *in situ*, whereas irradiation foaming does not involve heating and has the additional advantages that the foaming action is readily controllable by the dose received and that other reactions which may take place on irradiation could simultaneously produce an improved product.

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5 *Irradiation foaming of silicone rubber*

Fig. 5 shows an example of such foaming: a silicone-rubber stock consisting of a high-molecular-weight polydimethylsiloxane liquid was admixed with a fine polythene powder and a radiation-sensitive blowing agent to produce a paste of soft putty-like consistency; the irradiation of this mixture (Fig. 5a) caused the blowing agent to decompose, so foaming the paste and simultaneously cross-linking the silicone rubber to give a form-stable foam (Fig. 5b).

Other materials suitable for irradiation foaming are natural rubber and those synthetic rubbers which cross-link on irradiation. Furthermore, it is evident that all liquids which may be polymerized to a solid by irradiation could be simultaneously foamed, but this is only possible, first, if the material can be processed into a paste of suitable consistency and, secondly, if the polymerization rate and foaming rate can be suitably adjusted.

Acknowledgment

The author wishes to thank the Director of Research and Education, Associated Electrical Industries (Manchester) Ltd., for permission to publish this article.

Summary

Irradiation with 4 MeV electrons has been successfully employed in the production of a high-electric-strength and low-loss dielectric, in the post-treatment of certain insulators to improve heat and solvent resistance or adhesion characteristics, and in the production of insulating foams without heating.

The high dose-rate, penetration, and controllability of electron radiation derived from a linear accelerator make it ideally suited to this type of work.

Advisory Council on Scientific Policy

THE annual report* of the Advisory Council on Scientific Policy for 1959–60 is now available; extracts are given here without comment to highlight a few remarks of interest.

On general problems: 'It has become increasingly clear that the growing points in science are found most frequently in areas lying between the traditional disciplines and involve the participation of several of them'.

On expenditure: 'Figures suggest, subject to the great reservations which must always be attached to international comparisons of this kind, that the United States is devoting a somewhat larger portion of its resources to research and development than the United Kingdom (2·74% in 1958, as against 2·35% for the U.K.)'.

'Although small in comparison with our current expenditure on technological development, the sums already devoted to science in the universities are substantially greater than those devoted to the non-scientific disciplines.'

On mathematics: 'It has been represented to us that in pure mathematics we have perhaps persisted too long with the tradition of the lone worker, with the result that we are losing ground not only to the U.S.A. and U.S.S.R. but also to smaller countries'.

* Cmnd. 1167 (H.M.S.O., London, 1960).

On applied science: 'An example, where applied research directly affects the well-being of society, is the need for work on the measurement and suppression of noise'.

On the application of existing scientific knowledge: 'The problem of the development contract in civil industry is very difficult, though not we believe insoluble, when Government is not the direct customer, and has not, through an established design and contracting organization, laid down in detail the specifications and the objectives'.

On technical information: 'The Council feel that serious research into the whole problem of collation and dissemination of scientific information should be undertaken forthwith, possibly under the auspices of the new National Science Lending and Reference Libraries and in association with international efforts in this sphere'.

On the organization of research: 'A high level of scientific activity is expensive; science must help to pay by providing, in the short term, the means by which its continued growth can be supported'.

On education: 'We consider that specialization in schools has gone too far, and that in it originates the much discussed "gulf" between scientists and non-scientists'.

Design of lightning-proof h.v. transmission lines

621.315.1:621.316.98

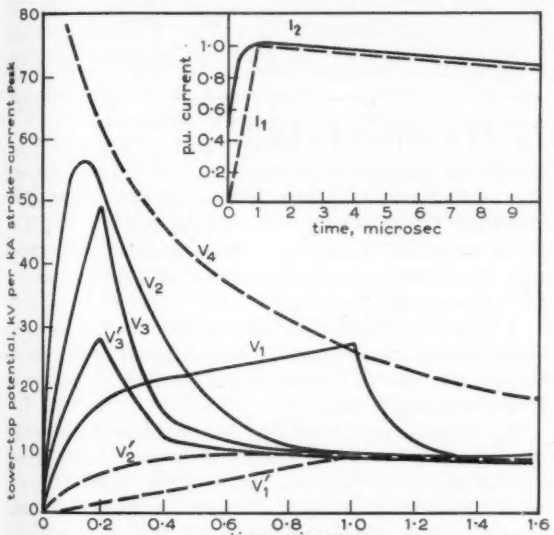
Lightning disturbances resulting from direct strokes are usually a principal consideration in the insulation of transmission lines up to the highest voltages now in use. In this article, which is an abstract of the Chairman's Address to the Calcutta Branch of The Institution on the 9th December 1959, the author confines his remarks to the electrical characteristics of transmission-line design. Mr. Bhaumik is Chief Electrical Engineer and Electrical Adviser to the Government of West Bengal.

A. K. BHAUMIK, B.SC.(ENG.), MEMBER

THE basic considerations for transmission-line design are efficient shielding, adequate insulation of clearances and low tower-footing impedances.

Considerable theoretical work by Monteith and others in the United States on lightning performance has established an easy graphical method—known as the conventional method. Design curves are prepared on the assumption that the lightning stroke is of a 2/40 microsec wave and intercepted by one or more overhead earth wires efficiently bonded to the metal support.

This conventional method, though extremely helpful in preliminary design, has limitations. The actual parameters on which the various curves have been based are not precisely known, and further investigations are necessary, reviewing the whole direct-stroke theory of transmission lines as to the steepness of wavefront of stroke current and the nature of inductance offered by the tower. Transmission-line engineers have found several instances of high lightning outages for transmission lines having long spans, high towers and one shield wire, even where the tower-footing resistances are very low, of the order of 2–5 ohms.



1 *Tower-top potential waves obtained by different methods of computation*

Earth-wire surge impedance = 400 ohms
Tower-footing resistance = 10 ohms
Tower inductance L = 20 μH
Tower surge impedance = 110 ohms
Tower height = 100 ft

Current waves:
I_1 = linear form of 1/40 microsec wave
I_2 = exponential form of 1/40 microsec wave more commonly used

Tower-top voltage waves:
V_1 includes L; calculated using current waveform I_1
V_1' neglects L; calculated using I_1
V_2 includes L; calculated using I_2
V_2' neglects L; calculated as above
V_3 is calculated by travelling-wave method using tower surge impedance
V_3' is calculated by travelling-wave method using two sets of additional earth wires, each having surge impedance of about 200 ohms
V_4 is the hypothetical voltage/time insulator curve

Effect of current

The effect of steepness of current for a 1 microsec wavefront with assumed inductance, or with tower surge impedance, can be readily understood from the curves in Fig. 1. These illustrate the calculated tower-top potentials obtained by different methods of analysis. The results of the analysis show that the tower-top potential indicated by V_1 and V_1' coincides in time with the peak of the stroke-current wave I_1. This is because the $L\,di/dt$ component of potential due to tower current is at its maximum as the peak of the stroke-current wave is approached, assuming the rate of current rise from zero to peak is uniform.

The current wave I_2 in its exponential form of representation, however, initially rises more rapidly than the linear form I_1, but its slope di/dt is continuously decreasing and becomes zero at the peak of the wave. Thus, while the $L\,di/dt$ component of voltage is rather large at the beginning of the wave, it becomes smaller and smaller until it reaches zero at the stroke-current peak. Voltage waveshape, indicated by V_2, points to this property of the current wave.

Travelling-wave theory

According to the travelling-wave method of analysis, the stroke current is considered to be flowing into a net surge impedance obtained by taking into consideration the surge impedances of the tower and earth-wire system in each direction, all being in parallel. The tower-top voltage increases until the first reflected wave of opposite polarity returns from the tower base and alleviates the voltage rise. Thereafter the voltage decreases, and after a series of reflections between top and base the surge

impedance of the tower cancels out, leaving only the footing resistance to produce tower voltage.

The peak tower-top voltage occurs at or near that time required for a voltage wave to travel to the tower base and return to the top. This is indicated by curve V_3 in Fig. 1.

From a study of different methods of analysis, it is clear that the tower-top potential, using either an exponential form of stroke-current wave (I_2) or the travelling-wave theory, is very severe when its relation to the voltage/time curve of an insulator string is considered, as shown by curve V_4.

Curve V_3' shows the effect of reduced surge impedance on tower-top potential, obtained by using two sets of additional earth wires in a tower top. Use of additional earth wires also reduces the effect of lumped inductance on tower-top potential.

Conclusion

Two aspects of the problem have to be faced: treatment of transmission lines already built having a large number of outages; and design of lightning-proof transmission lines with improved performance so as to reduce outages to the barest minimum.

Remedial measures suggested in the case of existing lines are:

1. To obtain low tower-footing resistance of the order of 10 ohms
2. To increase midspan clearance by allowing the earth wires to sag less than the conductors
3. To add one or more insulator discs in the insulator string
4. To provide two additional sets of earth wires, each with one end securely clamped at the tower top and the other on a 30 ft-long steel pipe or pole erected 60 ft away on each side of the tower across the line alignment, to minimize the effects of tower surge impedance and tower-footing resistance.

For designing new lines, however, adoption of the following is suggested:

(a) Shorter span and tower
(b) Correct assumption of isoceraunic level to calculate probable number of outages more precisely, and use of two earth wires if the isoceraunic level is higher than 50
(c) Use of disc insulators with larger withstand voltage for steep wavefront for the same over-all length of string.

BRITISH CONFERENCE ON AUTOMATION AND COMPUTATION

THE rapid growth of automation, including computation, process control and data-processing generally, led in 1957 to a decision by some 20 societies interested in these fields, or in their social and economic implications, to set up a central organization to provide more effective liaison between the interested bodies, to be known as the British Conference on Automation and Computation.

The Conference was divided into three autonomous groups, namely the British Group for the Engineering Applications of Automation, the British Group for Computation and Automatic Control, and the British Group for the Sociological and Economic Aspects of Automation Techniques.

At meetings of the three groups held on Monday, 10th October 1960, it was agreed that the Conference would operate more effectively under a central Council, and, accordingly, the groups agreed to merge in a reconstituted organization. At the first (constitutive) meeting of the Council of the reconstituted B.C.A.C. which followed, it was announced that the following societies had transferred their membership to the new body: Association of Certified and Corporate Accountants; British Computer Society Ltd.; British Institute of Management; British Productivity Council; Chartered Institute of Secretaries; the Institutes of Cost and Works Accountants, Fuel, Marine Engineers, Materials Handling, Metals, Personnel Management, Petroleum, Physics and the Physical Society, Welding; the Institutions of Chemical Engineers, Civil Engineers, Electrical Engineers, Engineering Inspection, Gas Engineers, Mechanical Engineers, Mining Engineers, Municipal Engineers, Plant Engineers, Production Engineers, Structural Engineers, Water Engineers; Iron and Steel Institute; Royal Aeronautical Society; Society of Instrument Technology; Tavistock Institute of Human Relations; and Trades Union Congress. The D.S.I.R. is observer. The following were adopted as objects:

1. To stimulate interest in, to spread knowledge of and to foster the development and applications of automatic control and computation
2. To afford a common meeting ground for the adhering organizations whereby such of their activities as fall within the purview of the Conference can, if they so desire, be co-ordinated and extended
3. To encourage and, if desired, to co-ordinate the presentation at international conferences of British papers whose subjects fall within the purview of the Conference
4. To maintain, as may be desirable, liaison with other countries which support such international conferences.

Sir Walter Puckey was elected Chairman of the Conference, with Messrs. L. T. Blakeman, J. F. Coales and H. G. Conway as Vice-Chairmen. Mr. S. M. Rix was elected Honorary Treasurer and Mr. W. K. Brasher Honorary Secretary, and the offer of The Institution to act as Secretariat was accepted.

Ten representatives from the above organizations were elected to serve with the Honorary Officers as the Executive Committee of the Conference.

At this meeting of the new B.C.A.C. Council, the members of the Conference, through their representatives, made arrangements under which the B.C.A.C. would act as a clearing house for information on their activities in its field, and confirmed that details of these should continue to be published in the B.C.A.C. Bulletin, copies of which may be ordered from the Secretary of The Institution of Mechanical Engineers, by whom the Bulletin is published.

CORRESPONDENCE

PROGRESS IN DIELECTRICS—VOL. 2

CONTRIBUTORS to a series such as 'Progress in dielectrics' find themselves in a similar unhappy position to that of civil servants, when their work is unfairly criticized but they themselves are not named by their critic, so that they are unable to reply. Such a situation arises from Mr. C. G. Garton's review of Vol. 2 of this series in the August 1960 *Journal*, p. 501. Just as public servants rely on the Minister to defend their actions, so in this case it is the duty of the editor to answer such criticism.

Apart from the sparse sugar of praise with which Mr. Garton's caustic pill is coated, there is only a single point of criticism which he makes which appears valid, namely his correction of the third nuclear equation on p. 85. The rest is either distorted, incorrect or unfair.

Dr. Wyllie's account of dielectric theory is entitled 'An introductory survey' and, as stated in the preface, is to be followed by further articles, such as the important contribution by Prof. R. H. Cole, which will appear in Vol. 3. Dr. Wyllie is the first to recognize his indebtedness to Prof. Fröhlich's book, but his own approach is stimulating, and well over half his references are to work subsequent to the publication of this classic text.

The commendation of Dr. Curtis's article on polymers as 'very well done' is richly deserved, though three words may be considered a rather scant account of this masterly review of a vast field, with its 133 references.

Dr. Sutton's article on glass receives harsher treatment, apparently because it includes 'data of all ages'. The aim of a review is to summarize critically the present state of knowledge, whenever and wherever obtained, provided that it is still relevant. It appears that Mr. Garton would criticize even a reference to the atomic nucleus, because it was discovered by Rutherford in Manchester in 1911 (within 100 yards of where this letter is written) 'and is not, in 1960, a novelty'.

The article by Dr. Black and Prof. Charlesby on irradiated polymers earns praise as 'most original', but two of the three 'minor blemishes' detected by the reviewer are non-existent. 'Telekilocurie' is an accepted word, and the authors can hardly be blamed for its existence. The classification of fast neutrons with protons as 'densely ionizing particles' (p. 81) does *not* 'obscure the basically dissimilar origin of ionization in the two cases'. The ionization is, in fact, in both cases due to the same particles, namely protons, as lucidly explained by the authors on p. 84.

Dr. Brown's fine, original review of artificial dielectrics is described as 'a useful, brief introduction', a recognition at least that the author has achieved his purpose.

The article by Dr. Plessner and Mr. West on high-permittivity ceramics for capacitors seems to Mr. Garton 'somewhat alien to the rest of the book' since it is 'concerned largely with details of industrial techniques'. This is the 'ivory-tower' academic attitude *par excellence*, and it is startling to find it expressed by a member of the E.R.A. 'Progress in dielectrics' is devoted equally to technology as to science, and if the balance has been more towards the latter, this can be attributed to the reticence of industrial technologists to disclose their 'know-how'. Hence an authoritative original article on one of the major technological achievements in the dielectrics field during the last decade, the practical utilization of ferroelectric materials, merits a better reception than the cold shoulder.

It appears, therefore, that Mr. Garton's view that the second volume is 'in contrast with the first, which contained a substantial amount of original research reported at first hand' is ill-founded, and that his description of the first is equally applicable to its successor. Mr. Garton doubts whether 'understanding of the subject advances quickly enough to justify an annual review of progress' and urges delay in the publication of Vol. 3. Such doubts may be valid about the particular dielectrics field with which Mr. Garton is personally associated, but they are hardly tenable over the whole field of dielectric science and technology.

The main editorial problem is to keep pace with developments, rather than to call for a man with a red flag to impose restraint. Those interested in the theory of electric breakdown in solids, the theory of dielectric absorption and polarization, dielectric properties and molecular structure, the dielectric properties of water, recent American developments in cable insulation, and dielectric aerials and waveguides will find these topics dealt with in Vol. 3, to be published shortly on schedule.

To enable members to assess for themselves the merits or otherwise of Vol. 2, an additional copy has been presented to the Institution Library, while Mr. Garton has been invited to contribute an article, on a topic of his own choice, to Vol. 5.

J. B. BIRKS, PH.D., D.SC., ASSOCIATE MEMBER
General Editor, 'Progress in dielectrics'
The Physical Laboratories
The University
Manchester 13

22nd September 1960

LETTERS FREE AND EASY

YOUR article 'Letters free and easy' in the September 1960 *Journal*, p. 517, encourages me to do now that which I have long wished to do, which is to write to you about the way in which you publish 'Correspondence'.

May I suggest that it would encourage members to write to you, were you to publish their letters as such, and not as if they were signed statements. The human touch in writing a personal letter is, I think, emphasized by the traditional courtesies of 'Dear Sir,' and 'Yours faithfully'.

I know that to satisfy this plea for the inclusion of the personal touch would require a little more space, but this would be justified if it helped to restrain the trend in shedding the little courtesies in life, which is detrimental to human relationships and to the social education of youth.

A further suggestion is that the page concerned should be headed 'Letters to the Editor' and not 'Correspondence'. I

feel sure that 'Letters to the Editor' traditionally commenced and concluded will be looked for among the pages of the *Journal* with more interest than your present form of publication, which, I think, tends to encourage stilted and stereotyped phraseology.

It is hoped, Sir, that you will appreciate that this is not so much a letter of criticism as a suggestion to help you to attain your desire that members should write you free and easy letters.

F. C. FUKE, MEMBER
Wayside
144 Wellsway
27th September 1960 Bath

[It is felt that Mr. Fuke's suggestions are good ones, and it is intended to adopt them in future—Editor]

STANDARDIZATION COMMITTEES—A HEAVY DRAIN ON MANPOWER

MANY of us, while believing in standardization, recoil from the effort needed. Ten or twelve men, all senior in their field, may have to sit around a table for a whole day discussing points of terminology. If they refuse, valuable standards may not be written or, what is worse, second-rate standards may be.

Could not The Institution join with other bodies to sponsor some O and M research? There may well be a way of reducing this burden on busy men.

B. J. BENZIMRA, B.SC.(ENG.), ASSOCIATE MEMBER
Decca Radar Ltd.
Research Laboratory
Lyon Road
4th October 1960 Walton-on-Thames, Surrey

CYCLES OR HERTZ

PAPERS appearing in Institution publications have been so well edited that 'cycles per second' ('c/s'; not 'p : s', 'p.p.s') always appears in the finished article. This frequently causes the author and editorial staff some concern. In normal conversation, and even at Institution lectures etc., authors tend to use 'cycles' (and even more so 'megacycles'), and 'pulses per second'. The latter can be defended on grounds of accuracy.

I propose that we adopt the Continental name for this unit—the hertz (h). Being a single syllable, it is unlikely to be abused and has the merit of applying to all periodic functions, even when a 'cycle' is not strictly observable (e.g. average pulse rate in Geiger-counting).

The term 'hertz' should not be unknown to British engineers, appearing as it does in, for example, Chambers's Technical Dictionary and on the panels of many Continental instruments.

Although personally convinced of the desirability of this change, I find it difficult to have the term more widely used owing to editorial rules (or conservatism), although the term was accepted in a recent paper (*Research*, July 1960, 13, p. 250). It would be interesting to have the views of other members and of the editorial staff.

W. H. P. LESLIE, B.SC., MEMBER
7 Threshold Park
7th October 1960 East Kilbride, Glasgow

[In the pages of the *Journal* and *Proceedings* we use the nomenclature, symbols and abbreviations recommended by the British Standards Institution, unless there is a very strong reason for departing from them. That 'cycles per second' (B.S. 1991, Part 1) should be printed 'c/s' and, frequently, read aloud as 'cycles' has not caused any concern to the editorial staff, nor has an author ever discussed the matter with us. For pulse repetition frequency we use the abbreviation 'pulses/sec'.

In the 'Remarks' column of the International Organisation for Standardization's Recommendation R31, Part 1, on quantities and units of periodic and aperiodic phenomena (item 2–3.a), it is stated that the hertz is also called in English 'cycle per second, c/s' and in French 'période par seconde, p/s'.

Copies of Mr. Leslie's letter and of any comments received from readers will be sent to the British Standards Institution for the consideration of the appropriate committee—Editor]

JUNCTION TRANSISTORS AND THEIR APPLICATIONS

IN his letter (October 1960 *Journal*, p. 598), Mr. O. D. Robinson has asked whether we go back over 100 years to the days of the 'two-fluid' theory of two separate kinds of electricity, positive and negative. I would reply that this is in fact what we have to do when we concern ourselves with semiconductors.

When dealing with semiconductors, it is no longer possible to regard the flow of current as being only a flow of electrons; the reason for this is that there are two distinct types of semiconductor—both types can have the same resistivity but they behave in different manners when joined together or joined individually to a metallic conductor. This behaviour can be reasonably described only by considering that in one type of semiconductor the current is caused by a flow of electrons, and that in the other the current is caused by a flow of holes.

Further illustration of the necessity for holes and electrons can best be made by referring to the action in the base of a transistor during the build-up and decay of current. To make the current flow in the base, the transistor has to be given a certain charge, and, in a similar manner, to reduce this current flow to zero, a certain charge has to be removed from the transistor. An equilibrium condition is set up in the base during the current flow by an equal number of holes and electrons, thus maintaining a charge without altering the base potential.

When the transistor is switched off (*p–n–p* transistor), the electrons leave by the base and the holes by the collector, thus maintaining a current flow between base and collector until the base is completely discharged. If, however, the charge is not removed in this manner, the base returns to its normal condition, because the holes and electrons combine together over a period of time determined by the lifetime of the base material.

I would point out, however, that this concept is applicable only to semiconductors and not to conductors or insulators.

E. WOLFENDALE, B.SC., ASSOCIATE MEMBER
Mullard Southampton Works
Millbrook Industrial Estate
Southampton, Hants.

11th October 1960

A GRAPHICAL SOLUTION OF THE KELVIN EQUATION

THE graphical solution of the Kelvin equation which is described in the September 1960 *Journal*, p. 536, can be used to determine the current in a circuit in which the inductance varies with the current, such as one with an iron core. The values of the 'time-constant' corresponding to the different values of the inductance can be plotted as abscissae against the current ordinates, and the slope of the current curve at any instant can thus be found. The current curve can then be plotted by the method described.

This curve cannot be determined from the mathematical solution of the equation.

E. W. MARCHANT, D.SC., F.C.G.I.,
PAST-PRESIDENT, HONORARY MEMBER
Brook Farm, Grendon
Atherstone, Warwickshire

12th October 1960

THE XIIIth GENERAL ASSEMBLY OF U.R.S.I.

THE International Scientific Radio Union, usually referred to by the initial letters of its French title—U.R.S.I., held its XIIIth General Assembly at University College London from the 5th to 15th September 1960. U.R.S.I. is associated with the International Council of Scientific Unions, which is a special organization under the United Nations. Its aims are to foster international co-operation in radio research, and to promote the use of agreed methods of measurement and nomenclature. The results of its work supply the fundamental knowledge on which all applications of radio are developed and maintained.

Its studies are complementary to those of the International Radio Consultative Committee (C.C.I.R.), which is concerned with the practice of radio and its application to communication, navigation and sound and television broadcasting, and with the acquisition of the technical knowledge that is necessary for the international allotment of frequencies on a sound and equitable basis.

U.R.S.I. is essentially a federation of national organizations, such as the British National Committee for Scientific Radio of the Royal Society and the corresponding committees under the Academies of Science in other countries. Apart from interim meetings of the board of officers of the Union, general assemblies of U.R.S.I. are held every two or three years in one of the member-countries. The three previous assemblies were held in Sydney (1952), The Hague (1954) and Boulder, Colorado (1957).

The last occasion when U.R.S.I. met in London was in 1934, when there were fewer than 50 delegates; in September 1960 there were over 600, this increase illustrating the growth in activity of U.R.S.I. over the past 26 years. The recent meetings in London were held under the presidency of Dr. L. V. Berkner (U.S.A.); and the Secretary-General of the Union is Ing. E. Herbays, who has his central office at 7 place Émile Danco, Brussels 18.

Scientific programme

The work of the Union is divided among seven commissions, dealing with individual aspects of scientific radio, as indicated by their titles. These, together with the names of their chairmen at the recent meetings, are as follows:

I. Radio measurements and standards	M. B. Decaux (France)
II. Radio and troposphere	Dr. R. L. Smith-Rose (U.K.)
III. Ionospheric radio	Dr. D. F. Martyn (Australia)
IV. Radio noise of terrestrial origin	Prof. R. A. Helliwell (U.S.A.)
V. Radio astronomy	Prof. A. C. B. Lovell (U.K.)
VI. Radio waves and circuits	Prof. S. Silver (U.S.A.)
VII. Radioelectronics	Prof. W. G. Shepherd (U.S.A.)

The programme was arranged so that all these commissions met concurrently to discuss subjects which, with one or more introductory speakers, had been selected previously by a meeting of officers of the Union and chairmen of commissions held in Brussels in 1959. A few joint sessions were also held to deal with subjects of common interest to two or more commissions.

Measurements and standards

Under the auspices of Commission I, considerable attention was devoted to reviewing the results of international comparisons of the standards of frequency and power and, particularly, the application of frequency standards to the emission of time signals for world-wide use in various fields of scientific research and application. Since radio time signals are interlinked with frequency, it was recommended that the Bureau International de l'Heure (B.I.H.) should in future select and announce a nominal value of frequency in terms of that of the caesium atomic standard, so that this could be used by institutions wishing to transmit uniform time and constant frequency in close relationship with the values used by astronomical observatories.

During 1958–60 an intercomparison had been carried out between laboratories in Japan, the United Kingdom and the United States of the measurement of power in the range 1–100mW at a frequency of 9·375 Gc/s (corresponding to a wavelength of about 3·2 cm). The results showed that the accuracy obtained by the techniques used in the three countries agreed to within 1·5–2%. It was considered desirable to extend this work to 140 Gc/s and to conduct similar experiments on other electrical parameters (e.g. voltage and attenuation) used in radio research.

Propagation of radio waves

The work of Commission II was primarily concerned with the relationship between the propagation of short radio waves and the physical characteristics of the lower atmosphere. The results of experiments conducted in some European countries and in America revealed the main features associated with wave propagation, first in the horizon range, and

then to both moderate and relatively great distances beyond the horizon. The scattering of radio waves from irregularities in the atmosphere received considerable attention, and the contributions from meteorologists interested in radio-propagation theories produced some lively discussions.

Since the previous general assembly at Boulder, a working group of Commission III has studied the utility of the relationship between ionization density and height—the $N(h)$ profile as it is called—as an effective measure of conditions in the ionosphere. The group reported to the commission that the $N(h)$ profile was useful for research purposes and had been used with advantage in comparing experimental measurements obtained in rockets with those given by ionospheric sounding equipment on the ground.

Another committee which had been active between the general assemblies was concerned with the co-ordination and publication of the results of ionospheric measurements made during the International Geophysical Year of 1957–58, and continued on a somewhat reduced scale during 1959. This had formed a useful arrangement for co-ordinating the activities of all ionospheric observatories, and it was recommended that it should be continued in the future. It was also agreed that the four World Data Centres set up at Moscow, Slough, Tokio and Washington for the collection and exchange of all radio results during the I.G.Y. should be continued on a permanent basis.

Other major items of discussion at the meetings of Commission III were concerned with the use of rocket and satellite techniques for exploring the ionosphere, and with the investigation of drifts of ionization and the scattering of waves by irregularities in the ionosphere.

The programme of Commission IV provided for discussions on the properties of natural radio noise, its origin in lightning flashes, and a review of our knowledge of 'whistlers' and their interpretation. The study of atmospheric radio noise involves an understanding of the propagation of very-low-frequency waves: and it was opportune that a joint session of Commissions III and IV should be devoted to a discussion of hydromagnetic waves and the propagation of v.l.f. waves. It was considered that more detailed knowledge was necessary of the changes in amplitude and phase of the waves during such propagation. This subject is of interest also in connection with the present tendency to use very low frequencies for standard-frequency transmissions from highly stabilized transmitters.

The members of Commission IV agreed that it was becoming necessary to standardize the terminology used in radio-noise phenomena, including 'atmospheric radio noise', 'ionospheric radio noise' and 'whistlers'.

Radio astronomy

Part of the programme of Commission V was devoted to reviews of progress in the subjects of radiation from the galaxy and from discrete sources in the universe; while particular attention was given to radioemission from both the quiet and the active sun. At a further session, the application of radio-echo technique to the study of meteors and planets was the topic of discussion. A joint session was held with Commissions VI and VII to review the present position and prospects of sensitive receivers, including parametric amplifiers, for various fields of radio research.

In view of the great activity in radio astronomy in various countries, Commission V emphasized the need for a fast abstracting service and a current index to the relevant scientific literature. The possibility of doing this in co-operation with other organizations, including the International Astronomical Union (I.A.U.), is to be explored.

Surface waves and electronics

The combined range of activities of Commissions VI and VII was very wide, and covered studies of surface waves, the properties of ferrites, aerials and sensitive receivers, as well as thermoelectricity, circuit theory and data-processing.

At one session, Commission VI discussed the constitution and characteristic properties of a surface wave propagated along the interface between two media. Apparently, scientific workers in this subject have divergent views; and one delegate referred to what he termed the 'religious fervour' which existed among the exponents of these views. As Prof. H. E. M. Barlow pointed out from the chair, although the term 'surface wave' was originally applied by Sommerfeld in a much wider sense than is customary today, there are nowadays so many variants of the surface-wave concept that it seems unlikely that any precise and, at the same time, useful definition can be formulated. It was agreed that to pursue the matter of terminology applied to surface waves would be unprofitable.

Space research

It was natural to find that during the general assembly a morning session was allotted to the radio aspects of space research. Part of the discussion at this meeting concerned the use of rockets and satellites for exploring the upper reaches of the ionosphere and for measuring the solar ionizing radiation and cosmic noise at great heights. Other papers dealt with the possibilities of both active and passive satellites for radio relay and communication systems between distant points on the Earth's surface.

One of the proposals discussed involved the discharge from a satellite of large quantities of small metallic filaments to form a belt of microwave-resonant dipoles in a circular orbit at an altitude of a few thousand kilometres. Such a belt or ring would reflect radio waves of a suitable frequency, and so could be used for communication between stations on the Earth some thousands of miles apart. As was pointed out at the meeting, however, such a screen of 'needles'—as it is termed—could form a serious menace to both optical and radio astronomy, in presenting a permanent echo or glare at the appropriate wavelength. U.R.S.I. was requested by Commission V to take urgent steps in consultation with the I.A.U. to ensure that such projects will not endanger future astronomical research.

Closing session

At the closing plenary session held on the 15th September, the individual chairmen reported on the activities of their commissions and working parties during the general assembly, and put forward resolutions and recommendations for adoption by the Union.

The individual papers presented at the meetings of all commissions, together with reports of the scientific discussions, will be published as a special series of U.R.S.I. monographs in the near future.

At the closing session also, the following officers and commission chairmen were elected for the next triennium to prepare for and organize the next general assembly, which will be held in Tokio in 1963.

President	Dr. R. L. Smith-Rose (U.K.)
Vice-Presidents	M. B. Decaux (France)
	Prof. I. Koga (Japan)
	Mr. A. Prochorov (U.S.S.R.)
	Prof. G. A. Woonton (Canada)
Chairmen of the commissions	
I	Dr. V. Adelsberger (Germany)
II	M. P. Voge (France)
III	Mr. J. A. Ratcliffe (U.K.)
IV	Prof. R. A. Helliwell (U.S.A.)
V	Prof. A. C. B. Lovell (U.K.)
VI	Dr. J. Loeb (France)
VII	Prof. W. G. Shepherd (U.S.A.)

The Secretary-General of the Union remains Ing. Herbays, and the Honorary Treasurer is Prof. C. Manneback, both of Belgium.

Visits and social programme

Apart from the scientific meetings, participants in the general assembly were able to visit various organizations, including the National Physical Laboratory, the D.S.I.R. Radio Research Station, the research departments of the B.B.C. and the Post Office, the Royal Greenwich Observatory and Cambridge University. Two evening visits to the B.B.C. Television Centre were also arranged.

A banquet was held at the Guildhall of the City of London, offered by the British National Committee for Scientific Radio on behalf of the electronics industry; and receptions were given by Her Majesty's Government, The Institution of Electrical Engineers, the University of London and the Royal Society. An opportunity was also provided before and after the general assembly for participants to visit the Jodrell Bank experimental station of Manchester University.

While the ladies attending were able to take part in many of these technical and social visits, a separate programme was arranged for them to visit places of interest in and around London, including Kew Gardens, Windsor and the Royal Naval College and Maritime Museum, Greenwich.

R. L. SMITH-ROSE

MEETING OF THE COUNCIL OF THE INSTITUTION, 6th OCTOBER 1960

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 6th October 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, as some items are to be the subject of further discussion by the Council.

Constitution

In accordance with established custom, the retiring President formally introduced the incoming President, Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C.*, LL.D., B.SC., and invited him to take the chair. When Sir Hamish had done so, he moved a warm vote of thanks to Sir Willis Jackson for the very able manner in which he had presided over the meetings of the Council during the past session and for his work on behalf of The Institution; this was accorded unanimously.

On taking their seats for the first time, the new members of Council were then received by the President, each coming forward in turn to shake hands with Sir Hamish.

Retiring members of Council and Committees

Resolutions that the best thanks of the Council be accorded to retiring members of Council for their services on the Council, and to those members of Council and others whose services on the Committees of the Council and on Special Committees had terminated on the 30th September 1960 for their services on these Committees, were passed unanimously.

Membership

The Council gave final confirmation of the election of those candidates whose names had been published with the August 1960 *Journal*, to become effective from the 3rd October 1960. Taking these into account, the total membership at that date was 46 625.

Commonwealth Technical Training Week

Mr. S. E. Goodall, deputy chairman of the Education and Training Committee, introduced his Committee's recommendation that The Institution should take part in the Commonwealth Technical Training Week to be held from the 29th May to 4th June 1961. This had been organized at the suggestion of H.R.H. the Duke of Edinburgh and was intended to call attention to the very wide range of apprentice schemes and technical training programmes available for young people.

It was proposed that, during the week concerned, an exhibition representing careers in electrical engineering should be arranged in the Institution building and that there should be a programme of films and talks open to the general public. In addition to these activities, it was suggested that local Centre Committees should be asked to assist with careers conventions or exhibitions which might be organized by local authorities in their respective territories. Although the period of the Commonwealth Technical Training Week coincided with that of the Institution Summer Meeting, it was considered that it should be possible to arrange these activities without mutual interference. The Council approved the arrangements proposed.

Special Advisory Committee

Progress was noted on the issue of the Report of the Special Advisory Committee, as decided at the last meeting of the Council. It had been found possible to arrange for copies to be available for issue to all Corporate members and Associates by Friday, 14th October 1960; other members wishing to receive the report would be sent copies on application to the Secretary of The Institution (see October 1960 *Journal*, p. 613).

New sound-broadcasting headquarters

A brief article based on an Electronics and Communications Section paper (3213) entitled 'Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services' by F. Axon, D.C.M., Associate, and O. H. Barron, M.B.E., B.Sc., Associate Member. It was published individually in April 1960 and is republished this month in Part B of the Proceedings. It was read before the Electronics and Communications Section on the 2nd May 1960 at Savoy Place. The authors are with the British Broadcasting Corporation.*

THE B.B.C.'s Empire Service started in 1932 as a single programme in English. By 1938, this first phase came to an end, and increasing tension of the international situation led to the introduction of broadcasting in other languages.

The next phase was the very rapid expansion in wartime, and 43 languages were in use by 1940. After various temporary expedients, the need for greatly increased studio accommodation was met by developing three centres in the London area and one at Evesham. Although such a degree of dispersal had obvious advantages during a state of war, it had equally obvious disadvantages in time of peace, being wasteful of manpower and facilities as well as inconvenient from the administrative viewpoint.

Soon after the end of the war, therefore, plans were made for the concentration of all the B.B.C.'s External Services direction and studio facilities at Bush House, Aldwych, London, and these were completed by 1957.

The result has been the creation of a modern studio centre containing 36 studios (including three continuity suites), 14 recording rooms (equipped with 34 magnetic-tape and 16 disc machines), and an up-to-date control room, the lay-out of which is shown in Fig. 1.

1 *Lay-out of control room and associated areas*

* This article and that following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

Method of switching

It having been decided to build a new control room, consideration was first given to the type of switching to be employed.

The basic requirement was to be able to switch many sources, such as studio outputs, reproduction from disc and tape recordings, etc., to a large number of routes, such as lines to transmitters, inputs to recording channels, etc. Remote

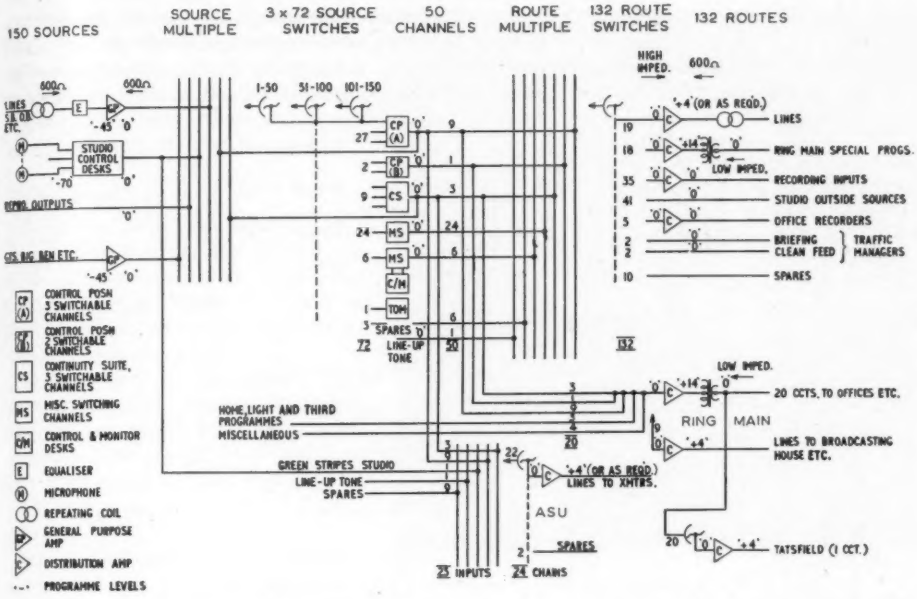
switching from desks in control positions and from the control room itself is the most practical solution for such a large installation, and the choice was between relays and motor-driven rotary switches. The former are more economical for small and medium installations, but motor-uniselector switches are preferable for large installations and were chosen for Bush House.

The practice in the External Services of the B.B.C. is to standardize programmes in multiples of a quarter-hour, allowing a few seconds between consecutive programmes for any necessary switching operations at the origin and/or destinations. The individual items are assembled into a programme in a continuity suite, which may include a studio for linking announcements.

The outputs of all the continuity suites are fed to the various transmitters according to a predetermined pattern which is set up for a period of 24 hours on an automatic switching unit, controlled by a master clock. Last-minute variations in the regular pattern can be carried out on a manual position in the control room. The master clock also operates all the slave dials throughout the building and is automatically corrected, if necessary, by hourly Greenwich time signals.

In addition to these regular switching operations and the selection of the sources required by the control positions, a miscellaneous switching position was designed to deal with the numerous day-to-day switching operations. This desk is located in the control room and deals with such things as traffic to and from recording and reproducing suites, programmes through the Continental Trunk Exchange, etc.

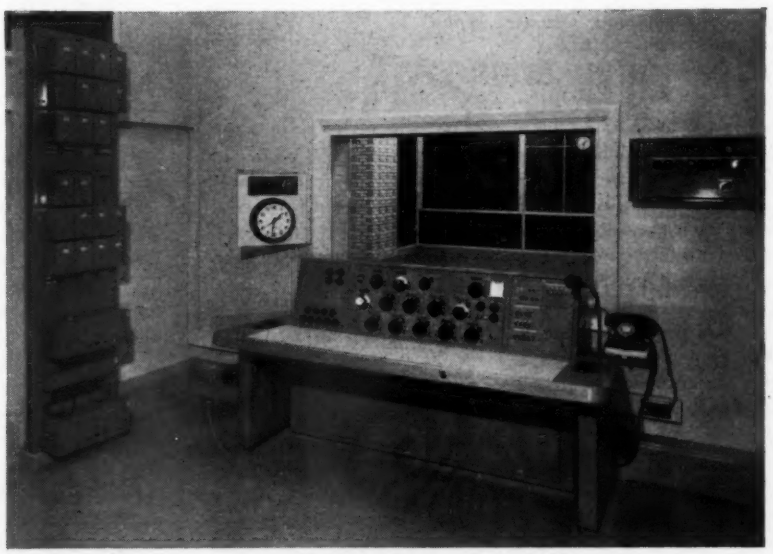
The installation was designed initially for 150 sources switchable to 132 routes, in addition to those permanently connected to the automatic switching unit and some other fixed destinations. Fig. 2 is a simplified programme switching block schematic.



2 *Programme-switching block schematic*

Ring-main monitoring

All the External Services and the B.B.C.'s domestic

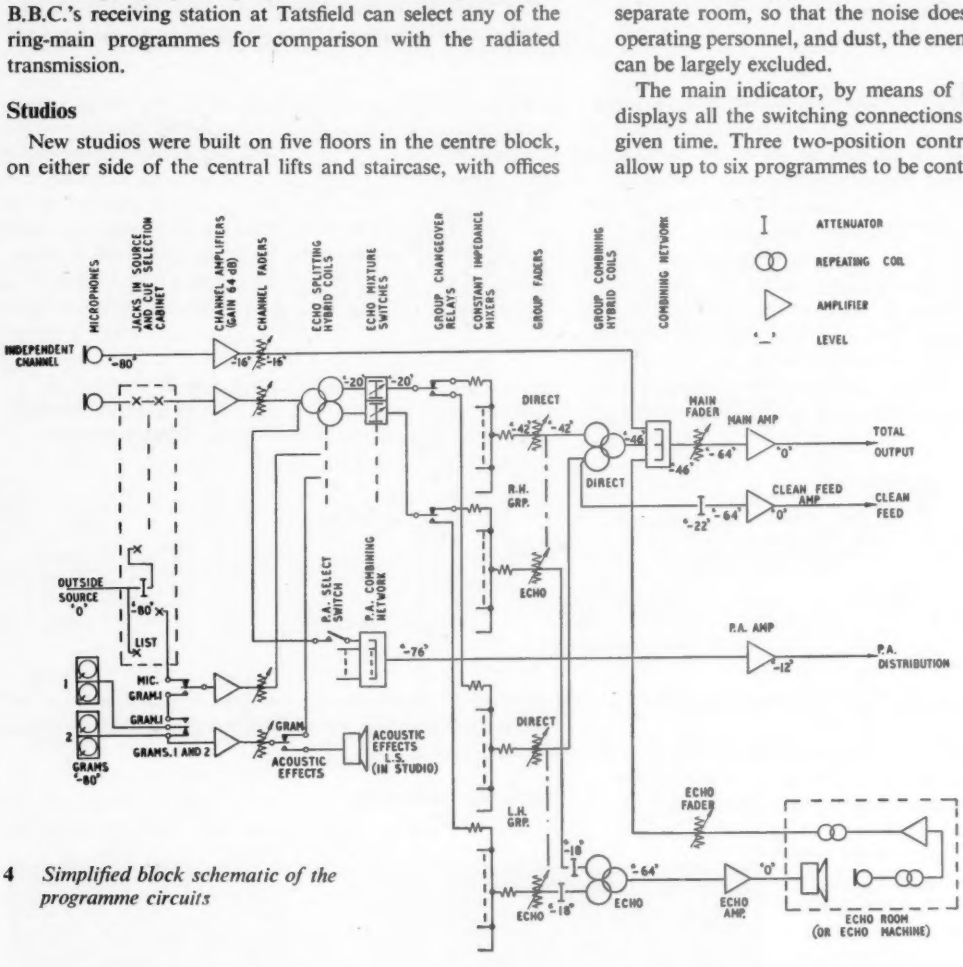


3 *General-purpose studio control desk and associated amplifiers*

programmes are available on a ring-main system for listening purposes throughout the building. Facilities are also provided for feeding any special programmes over this system. The B.B.C.'s receiving station at Tatsfield can select any of the ring-main programmes for comparison with the radiated transmission.

Studios

New studios were built on five floors in the centre block, on either side of the central lifts and staircase, with offices



4 *Simplified block schematic of the programme circuits*

arranged around the outside. They are mechanically ventilated by washed and tempered air. Adequate sound insulation was obtained by employing 'floating' floors of light-weight concrete on a glass-fibre mattress and a wall construction comprising two separate skins. The acoustic treatment was designed to achieve a flat reverberation time of 0·35 sec.

The latest B.B.C. designs of equipment were installed. Fig. 3 shows a general-purpose studio control desk and associated bay of amplifiers. Fig. 4 is a simplified block schematic of the programme circuits. The design is such that various arrangements can readily be made by selecting suitable sub-assemblies.

Technical arrangements

Tape recording and reproducing facilities include two central tape rooms, each with facilities for remotely controlled recording or reproduction of ten programmes simultaneously.

The control room and associated technical areas house all the switching equipment and bays of amplifiers, relays, etc. The switching equipment, being unmanned, is located in a separate room, so that the noise does not interfere with the operating personnel, and dust, the enemy of reliable operation, can be largely excluded.

The main indicator, by means of lighted code numbers, displays all the switching connections which are set up at a given time. Three two-position control and monitor desks allow up to six programmes to be continuously monitored, as distinct from the general monitoring provisions of the main operating position.

An engineering manual exchange forms an important part of the main desk and deals with all technical inquiries over the network of control lines.

The technical operations manager is responsible for all technical matters, and his cubicle is equipped with comprehensive monitoring facilities.

Power for all areas is normally drawn from the supply mains. In the event of a complete mains failure, essential services and emergency lighting are maintained by auto-start Diesel generators.

Cables and wiring

The decision to proceed with the project was taken in March 1955. The design and manufacture of the equipment had proceeded far enough for installation to start in May 1956.

The installation was carried out almost entirely in 6½lb plastic-covered single pairs or multicored cables. Screening was used throughout, either for the individual pairs or over-all, depending on the nature of the circuits. Over 40 miles of cable were used, excluding that for the manufacture of bays, desks, etc. Testing commenced in June 1957, and the first network was transferred in September. By November, the control room, new studios and recording suites were fully operational. All the work was planned and carried through without any disturbance to the flow of programmes.

Saving in staff

On the engineering side alone, the staff saving directly attributable to the final stages of the concentration of External Services at Bush House is already of the order of 40. At the same time, commitments have increased.

The technical operations are now practically cordless; hence they are more accurate and much less tiring, while automatic switching has removed a great deal of the drudgery from control-room work, with a higher standard of reliability.

Many additional facilities have been incorporated in the new equipment, such as remote starting and stopping of tape machines from studio cubicles and continuity positions; the provision of control and monitor positions; and separate central tape recording and reproducing rooms (see Fig. 5), requiring a minimum number of operators.

Supervision of the ten continuity positions controlling the various programme networks has been much improved through their grouping in the control-room area adjacent to the technical operations manager, together with the provision of loudspeaker intercommunication with 'conference' facilities between him and the operators at these positions.

5 *Central tape room*

Bush House represents a further important step forward in the design of modern sound-studio and control-room equipment on the largest scale, and similar installations will be incorporated in the extension to Broadcasting House and the Television Centre.

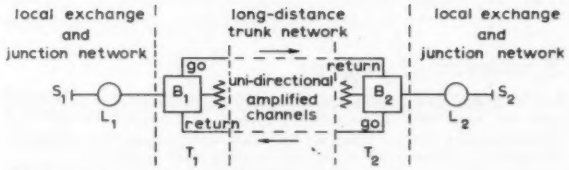
621.396.712:654.19

Telephone echo tests

A brief article based on an Electronics and Communications Section paper (3338) with the above title by D. L. Richards, B.Sc.(Eng.), and G. A. Buck, Associate Members. The paper is published this month in Part B of the Proceedings. The authors are at the Post Office Engineering Research Station.

The local exchange and short-distance junction telephone network uses equipment through which speech can be transmitted in either direction (2-wire transmission). Long-distance connections, however, are made over circuits which must be amplified, and this is facilitated by separation of the 'go' and 'return' channels (4-wire transmission). Fig. 1 shows the arrangement.

Connection between 2-wire and 4-wire portions is made with terminating units which establish the separation by providing good transmission paths from the 2-wire sides to the go channels and from the return channels to the 2-wire sides. By means of impedance balances, they also maintain as large a loss as possible (termed the 'return loss'*) between return and go channels.



1 *Long-distance telephone connection*

S_1, S_2 subscribers' stations
L_1, L_2 local exchanges
T_1, T_2 terminations of long-distance circuit at trunk exchanges
B_1, B_2 terminating units

Unfortunately, the maximum loss obtainable is not very

* For simplicity, it is assumed here that the terminating units have amplifiers incorporated so that the paths 2-wire to GO and RETURN to 2-wire have zero loss. In practice, the loss in each of these paths of some 4 dB is compensated for by additional gain in the unidirectional amplified channels.

great, owing to compromise in matching to the impedance of the local exchange and junction network; 6dB or less is typical. The long-distance amplified channels are subject to transmission delay due to the finite propagation speed of the signals, perhaps 1millisec per 100 miles for modern line plant.

Transmission delay

Speech from a person talking at S_1 will proceed via L_1 to T_1, then to the go side of B_1, the amplified channel from T_1 to T_2, through B_2 and L_2, to the person listening at S_2. This listener will hear the speech somewhat later than it leaves S_1, owing to the transmission delay between T_1 and T_2; this will not be noticed unless the delay exceeds, say, 100millisec. What may be important, however, is the delayed speech which enters the return side of B_2 and is reflected out of the go side eventually to return, after further delay between T_2 and T_1, and be heard by the talker at S_1.

A telephone user normally hears his own voice through the air path to his free ear and through the sidetone path of his telephone set. The presence of the latter path does not matter because it does not delay the speech and is, in any modern set, sufficiently attenuated. The effect of hearing one's own speech after some tens of milliseconds' delay is to experience echo which, if loud, proves at least unpleasant and perhaps even very disturbing when one is speaking continuously.

For a given telephone set and a given talker, the subjective disturbing effect of talker echo depends mainly on two factors, namely the amount of 'round-trip' delay and the extent to which speech signals from the telephone set are attenuated when they return to it. Of course, persons vary widely in their susceptibility, many accepting an echo condition which would be definitely objectionable to others. Prolonged exposure to talker echo may also affect susceptibility.

Tests for echo

Telephone networks are designed so that echo is rarely present but, when present, is not seriously disturbing. Tests to determine acceptable limits for talker echo must therefore be conducted using as subjects persons who are, as far as practicable, typical of ordinary telephone customers, and who are not, either before or during the tests, unduly exposed to the phenomenon.

The tests consist partly of conversations between pairs of subjects over specially set up speech links, in which the talker-echo conditions can be adjusted over a wide range. A great deal of the work, however, consists purely of talking tests, where a subject reads a test sentence lasting some 10–20sec. In either case, the subjects are asked to express opinions on the detectability or objectionableness of echoes having various delays and attenuated to various degrees.

The results are finally assembled in terms of the percentage of subjects who regard the echo as objectionable, as a function of the round-trip delay and the attenuation from their telephone-set to the point of reflection and back again. Naturally, the results depend somewhat on the design of the telephone set itself and the line to which it is connected, but these are minor variables. Some typical results are:

round-trip delay	echo-path attenuation needed to satisfy p% of subjects		
	$p = 80\%$	$p = 90\%$	$p = 95\%$
ms	dB	dB	dB
10	<0	3	6
20	5	10	13
30	11	15	19
40	15	20	24

Assuming 6dB return loss at the terminating unit remote from the talker (see Fig. 1), it will be seen that an over-all loss between S_1 and S_2 of only a few decibels (which is desirable to ensure good over-all transmission) will be accompanied by talker echo objectionable to a substantial percentage of persons, unless the round-trip delay is less than, say, 20millisec.

When the delay is large, either the over-all loss must be increased or echo suppressors inserted. These are voice-operated switching devices which introduce loss in one unidirectional channel while speech is being transmitted in the other. In some cases, special steps may be possible to improve the balance at the terminating units. 621.391.826.6

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. Reprints will be available about two months after publication

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Electricity meters

A synopsis of a Review of Progress (paper 3343) with the above title by G. F. Shotter, Member. The paper was published in October 1960 in Part A of the Proceedings.

THIS review on integrating electricity meters is, for convenience, based on the current British Standard (37) for these instruments. While in previous Standards all the various types of integrating meter were included in one document, in the current edition each class of meter is covered by a separate specification. The general clauses are included in the first document. This is a more logical arrangement, as each type of meter can be catered for according to the performance required.

Although no fundamental change in principle has occurred since the last review in 1936, improvements have been made, particularly to the single-phase house service meter, in the way of standardizing certain parts, e.g. fixing dimensions, terminal spacing, and terminal holes and clamping screws.

The reduction in the number of sizes of this instrument from six to three has been made possible by the extension of the accuracy load range from 25 : 1 and 40 : 1 to 60 : 1. The sizes chosen, 10, 40 and 80amp, which are maximum ratings, were based on some preliminary investigations into the

characteristics of consumers' loads. These instruments are now marked with their maximum continuous-current rating.

Reference is made in the review to the more comprehensive investigations of consumers' load characteristics.

The sizes of the single-phase prepayment meter are now reduced to two: 10 and 40amp.

A comparison is presented of the electrical performance of the various types of instrument under the old specification and the new. The factors governing the stability of a meter are discussed.

While the electrical performance is governed by the British Standard, the mechanical stability is also of great importance to the supply authority, who require sustained accuracy for as long as possible and a meter so designed that the cost of overhauling can be kept to the minimum.

Mention is made of the research that has gone into the bottom bearing of such instruments, which is the worst offender with regard to friction increase and instability at low loads.

Two other facts are noted—the greater use by manufacturers of high-energy anisotropic alloys for the damping magnets, and the development of better types of cyclometer register owing to the approval of these by the Ministry of Power.

More extensive use is being made of summation metering, particularly the impulse methods, for centralization purposes. There is a new type of instrument for the measurement of apparent-power maximum demand.

From the analysis of the factors investigated, it appears that the British meter now manufactured is in advance of those under review in 1937, particularly from the mechanical point of view, and that it compares favourably with the product of any other country. 621.317.785

Non-reflecting waveguide tapers

A synopsis of an Electronics and Communications Section paper (3318) with the above title by Prof. H. E. M. Barlow, B.Sc.(Eng.), Ph.D., M.I.Mech.E., Member. The paper is published this month in Part B of the Proceedings. The author is Pender Professor of Electrical Engineering, University College London.

MUCH work has already been done towards establishing techniques for tapering the cross-section of waveguides without introducing significant reflections when waves are propagated along them. The author approaches the problem from the aspect of maintaining a completely undisturbed field pattern outside the guide whatever its cross-section, so that the wave impedance remains constant.

Examples are given illustrating how this result may, in principle, be achieved both for the hollow metal guides of rectangular and circular cross-section and for single-wire transmission lines. On the basis proposed, the author shows that the surface impedance of the guide must always have a resistive component which has nothing to do with losses but is dependent solely on the angle of the taper and represents energy crossing the interface from the field on one side to the field on the other. 621.372.831.11

H_{10}-to-H_{20} mode transducer

A synopsis of an Electronics and Communications Section paper (3305) entitled 'A new H_{10}-to-H_{20} mode transducer' by C. C. Eaglesfield, M.A., Associate Member, Y. Klinger, Ph.D., and L. Solymar. The paper is published this month in Part B of the Proceedings. Mr. Eaglesfield and Mr. Solymar are with Standard Telecommunication Laboratories Ltd. Dr. Klinger, who was formerly with Standard Telecommunication Laboratories Ltd., is now at Battersea College of Advanced Technology.

USING a general method of mode-transducer design previously described, a simple H_{10}-to-H_{20} mode transducer was constructed. The reflection coefficient is calculated, and the authors show that for a transducer a few wavelengths in length the reflections are insignificant. The power transferred to the spurious modes was measured by the resonance method on two experimental models, two and eight guide-wavelengths long. The longer transducer transforms 92% of the power into the required mode. The power in unwanted modes can be greatly reduced by the use of a simple absorptive mode filter. 621.372.852.5

Recording of single-shot phenomena

A synopsis of an Electronics and Communications Section paper (3294) entitled 'The recording of high-speed single-shot phenomena' by F. E. Whiteway, B.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. Mr. Whiteway is at the U.K.A.E.A. Atomic Weapons Research Establishment.

TECHNIQUES at present in use for the recording of single shot phenomena by cathode-ray oscillographs are reviewed. Cathode-ray tubes are discussed, with particular attention to the conflicting requirements of high writing speed, wide bandwidth and high sensitivity. These requirements can be met to a large extent by the use of very small spot size and travelling-wave techniques. The author gives an account of associated circuits, including high-speed time-bases, amplifiers and calibration equipment. 621.317.75

High-resolution measuring system

A synopsis of a Measurement and Control Section paper (3312) entitled 'A high-resolution measuring system using coarse optical gratings' by B. J. Davies, B.Sc.(Eng.), Associate Member, R. C. Robbins, B.A., Associate Member, C. Wallis, B.Sc., and R. W. Wilde, B.Sc., Graduate. The paper is published this month in Part B of the Proceedings. The authors are with the Staveley Research Department (George Richards and Co. Ltd.).

THE authors describe a new measuring system, using 100 lines/in. optical gratings, which contains no moving parts and has been incorporated in both continuous-path and co-ordinate-setting control systems.

By a method of cyclic switching of four photocells and subsequent filtering of the combined photocell signals, an a.c. waveform is produced which can be compared in phase with a reference waveform, to determine the magnitude and direction of relative displacement between two gratings, and to provide linear interpolation within the pitch of the gratings.

The authors give details of the optical, mechanical and electronic design and discuss the effects of variables on the accuracy of the system.

Interpolation accuracy within $\pm 2 \times 10^{-4}$in., using 100 lines/in. gratings, has been achieved in practical systems.

621.317.39 : 621-526

Paraboloidal reflectors with axial excitation

A synopsis of an Electronics and Communications Section paper (3311) with the above title by A. R. Donaldson, B.Sc., Graduate, I.P. French, B.Sc., Student, and D. Midgley, B.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The authors were formerly at the University of St. Andrews. Mr. Donaldson is now with Associated Electrical Industries (Rugby) Ltd., Mr. French is with the Radio Corporation of America, and Dr. Midgley is Reader in Electrical Engineering at the Bradford Institute of Technology.

THE reflectors are deep paraboloids having axially oriented dipoles at the foci. Odd-function aperture distributions and radiation patterns are derived by approximate methods and are compared with an experimental polar diagram. In spite of a null along the axis, strong coupling at short range is observed between two aligned aerials. This is associated with a coupling diagram of abnormal directivity, which may be explained by a principle of field-fitting between the incident field and the normal aperture distribution. A reduction of Maxwell's equations in paraboloidal co-ordinates to Bessel's equation is appended. 621.396.677

Scatter-propagation measurements

A synopsis of an Electronics and Communications Section paper (3319) entitled 'Propagation measurements at 3480 and 9640 Mc/s beyond the radio horizon' by G. V. Geiger, B.Sc., N. D. La Frenais, B.Sc.(Eng.), and W. J. Lucas, M.Sc. The paper will be published in Part B of the Proceedings. The authors are in the Research Laboratories of The General Electric Co. Ltd., Wembley.

AN account is given of scatter-propagation measurements made at S- and X-band during the period May 1957–May 1959. The work at S-band continued throughout the whole of this time, while the X-band measurements were made during the period of a year from June 1958–May 1959.

The S-band transmitter, using a 3·480Gc/s c.w. magnetron with a power output of 500 watts, was established at Start Point in Devon. Receiving terminals were set up at Wembley, Middlesex, and Witnesham, Suffolk, at distances of 173 and 247 statute miles respectively from the transmitter, the former being maintained in operation throughout the whole of the experimental period and the latter for a period of nine months from September 1957 to June 1958.

Diurnal and seasonal variations in the median level of the received signal are discussed, and a comparison is made of measurements taken simultaneously at Wembley and Witnesham. The distribution of the S-band fading rate as a function of level is studied, and a limited amount of work concerned with the distribution of the duration of fades below a given level and the power spectrum of the detected signal is described.

The transmission path for the X-band system, which used a pulsed magnetron at a frequency of 9·640Gc/s, also lies between Start Point and Wembley; the pulse length was 2microsec and the pulse-repetition frequency 500c/s, the peak power in the pulses being 180kW. The X- and S-band links were operated together whenever possible, and the authors compare the median level and fading rate of the signals received simultaneously at the two frequencies over the same propagation path. In addition, they describe a series of measurements to investigate the aerial coupling loss of the X-band system. 621.391.812.624

Emission from miniature hollow cathodes

A synopsis of an Electronics and Communications Section paper (3333) with the above title by A. Sandor, M.E.E., D.E.Sc. The paper will be published in Part B of the Proceedings. The author is with the General Telephone and Electronics Laboratories Inc., New York, U.S.A.

MINIATURE hollow cathodes, internally coated with conventional oxides, have been studied. As visual inspection revealed, oxide deposits at the narrow orifice edge constricted the flow of electrons, and the initial emission from this edge was then spontaneously destroyed by saturation-caused deactivities, owing to positive-ion action. Large hexagonal crystal growth on the other nickel body was also observed. While the external field causes the electrons to emerge from the cavity as a laminar flow, the conditions in the internal cavity change abruptly to a gas discharge with large field, and at this point ion bombardment damages the coating. The emission characteristics suggest a strong temperature-dependence of the electron flow to an external collector.

Modified orifice arrangements showed that optimum emission is obtained with a sharp orifice edge and solid cavity walls, although no difference in emission was detected between a fully and a partly coated cavity. Grid-controlled operation revealed a decrease in transconductance owing to field shielding and to the receding virtual cathode, while the focusing quality suffered mainly by the added orifice lens.

The author attempts to interpret the mechanisms of current flow to an internal and an external anode. Since the emission characteristics do not reveal the presence of the underlying emission laws in an explicit form, emission is related to an

equivalent diode with dynamic perveance. Hollowness in the beam cross-section at higher currents is interpreted as the result of bunching near the orifice edge, localized current saturation, and of a weaker field along the axis.

621.385.032.213.13

Experiments on matrix cathodes

A synopsis of an Electronics and Communications Section paper (3363) entitled 'Pressed-oxide nickel-matrix cathode below apertured electrodes' by A. Sandor, M.E.E., D.E.Sc. The paper will be published in Part B of the Proceedings. The author is with the General Telephone and Electronics Laboratories Inc., New York, U.S.A.

CARBONYL-NICKEL powder pressed and sintered with alkaline-earth triple carbonates serves as an experimental emitter. The author investigates the general behaviour of this dispenser-type cathode in the severe field and ion-focusing conditions below closely spaced and apertured electrodes.

Locally-confined ionization processes in the alkaline vapour components will develop. The ion-focusing ability of the aperture, particularly if the surface-protecting space charge is removed, enhances evaporation. A spontaneous rise in cathode temperature accompanies this effect, leading to more vapour generation.

Deep pit formations will invalidate the advantage believed to exist in a well determinable surface profile. Negative grid control produces similar ionization effects because of the large centre field below the aperture.

The self-sustaining discharge, starting just beyond the saturation bend, will last as long as sufficient alkaline metal is available on the surface. Three discharge peaks were measured with gradually increased anode voltage, indicating the replenishing ability from within the matrix. A faster recovery from the discharge state at higher temperatures is explained by a higher deionization rate, owing to a more intense vaporization of nickel.

In the severe aperturing conditions the cathode is inferior to oxide-coated cathodes and also to dispenser-type cathodes with built-in chemical reaction and vapour controls.

621.385.032.213.13

Magnesium-oxide-coated cathodes

A synopsis of an Electronics and Communications Section paper (3344) entitled 'Electron emission from cold magnesium oxide' by H. N. Daglish, B.Sc., Ph.D., A.Inst.P., Graduate. The paper will be published in Part B of the Proceedings. The author is at the Post Office Research Station.

A POROUS layer of magnesium oxide may be used as a cold source of electrons in a vacuum tube, the emission depending on the maintenance of a positive electrostatic field through the oxide layer. The author describes methods of making and processing cathodes of this type, and shows that stable emission is obtained only from cathodes in a fully oxidized state. The behaviour of these cathodes in various experimental conditions has been examined with particular reference to voltage and temperature effects. 621.385.12.032.2

Television transmitting aerial in populous area

A synopsis of an Electronics and Communications Section paper (3334) entitled 'The use of a high-gain television transmitting aerial in a populous area' by G. D. Monteath, B.Sc., A.Inst.P., Associate Member, G. H. Millard, A.Inst.P., and D. J. Whythe, B.Sc.(Eng.), Associate Member. The paper will be published in Part B of the Proceedings. The authors are with the British Broadcasting Corporation.

THE authors are concerned with the provision of satisfactory signals to viewers in the immediate vicinity of the Crystal Palace television station, where an 8-tier aerial is sited in an urban area. The problem was complicated by differences between the halves of the aerial, but a satisfactory performance was ultimately obtained. The only serious discrepancy between theoretical and experimental results could be removed by taking account of reflection at the ground, ignoring the effect of buildings.

In order to provide continuity of service in spite of any single breakdown, the halves of the aerial were originally supplied from separate transmitters; this arrangement had to be abandoned, since it proved impossible to provide undistorted signals at receiving points where the contributions from the transmitters were in phase opposition.

621.396.677 : 621.397

Electron-beam parametric amplifier

A synopsis of an Electronics and Communications Section paper (3342) entitled 'An electron-beam parametric amplifier for the 200 Mc/s region' by G. O. Chalk, M.Sc. The paper will be published in Part B of the Proceedings. The author is with the English Electric Valve Co. Ltd.

THE author describes the design and performance of a low-noise electron-beam parametric amplifier of the quadrupole type. This is a transverse-field device, in that the electron beam interacts with a radio-frequency field transverse to its direction of motion.

Particular attention is directed to the conditions necessary to achieve the lowest over-all noise figure of the amplifier. It is shown that these also lead to the broadest amplification bandwidth.

The minimum noise figure so far obtained is 1·6dB at about 200Mc/s, which corresponds to an amplifier noise temperature of 130°K. This was obtained at an over-all gain of 10dB, which required about 2mW of pump power. The amplification bandwidth was 25Mc/s. These performance figures compare well with those reported for the original quadrupole amplifier at higher frequencies. 621.375.9

PAPERS AND MONOGRAPHS
published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available, they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

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PAPERS

Influence of ageing on the characteristics of oil-filled cable dielectric *Paper* 3348S, *Part A*

P. GAZZANA-PRIAROGGIA, DR.-ING., G. L. PALANDRI, DR.-ING., *and* U. A. PELAGATTI, DR.CHEM.

AN investigation has been made of the electrical and mechanical characteristics of the insulation of samples of cables in the range 60–230kV after many years of operation, in order to evaluate the influence of ageing on the dielectric of oil-filled cables. To determine the effect of thermal ageing alone and in combination with electrical stress, a long series of laboratory tests has been carried out on components of cable insulation, on cable models and on actual cables. A comparison has been made between the laboratory investigations and the state of the insulation of cables after many years of operation.

These conclusions have been reached:

(a) Paper is the component most affected by temperature
(b) The electric strength is not influenced, within the limits of the tests, by the combined effects of temperature and electric stress
(c) Cables examined after more than 20 years' operation are still in perfect condition and will go on operating satisfactorily for many more years if present loading conditions are maintained.

It is suggested that the mechanical deterioration of paper should be taken as a criterion of the state of used cables and that, for both new and used cables, the temperature limits for normal and emergency loading should be fixed in relation to the desired life of the cable.

Date of reading not yet fixed

An oscillating synchronous linear machine *Paper* 3351U, *Part A*

E. R. LAITHWAITE, M.SC., PH.D., *and* R. S. MAMAK, B.SC.

THE authors explain the development of a new type of a.c. generator in which the moving member travels within a d.c. pole structure in a straight line with reciprocating motion. The induced e.m.f. appears in the moving member, which consists of a single loop of conducting material which embraces and moves along the core. The core carries stationary coils which experience an induced alternating e.m.f. by transformer action from the moving loop. These coils are not associated with the air-gap between the d.c. poles and are more easily cooled than the windings of a rotary machine. The loop, which is confined to the air-gap, can be run at high temperature, since it carries no insulation.

The machine can be used as a generator to convert mechanical power supplied directly from a piston. It can also be used as a synchronous motor for such purposes as the driving of compressors without cranks; when used in this manner, the machine is self-starting. It is essentially a single-phase machine. The equivalent of multi-polar rotary machines can be constructed which will generate e.m.f.'s at 50c/s with mechanical oscillations at frequencies lower than 3000/min.

An experimental machine is described, the development of which consisted largely of testing devices to minimize the internal impedance. Test results are given.

The paper includes a proposed design for a 33kVA generator.

Date of reading not yet fixed

Silicon power rectifiers *Paper* 3362U, *Part A*

A. J. BLUNDELL, A. E. GARSIDE, B.SC.(ENG.), R. G. HIBBERD, B.SC., *and* I. WILLIAMS, B.SC.

THE silicon rectifier is now well established over a wide range of voltages and currents, and, in all probability, will remain as a standard class for many years to come.

The paper opens with a brief survey of the processes involved in the preparation of single-crystal silicon; this is followed by sections devoted to design considerations and process techniques used in the preparation of silicon rectifier cells.

The electrical properties and ratings of rectifier cells, and the factors involved in their operation in rectifying equipments, are discussed in some detail; brief mention is made of the various fields of application in which silicon rectifiers will offer advantage.

The latest device of this class—the silicon controlled rectifier—is described, and its importance for the future is emphasized.

Several theoretical aspects of the forward and reverse characteristics of silicon rectifier cells are treated in the Appendixes.

Date of reading not yet fixed

A general theory of depreciation of engineering plant *Paper* 3366S, *Part A*

D. RUDD, B.SC.(ENG.)

THE conventional methods of providing for the depreciation of engineering plant are criticized on the grounds that they contain arbitrary features, and a general theory is formulated which is not subject to such criticism. The general theory is applied first to individual projects, showing how the factors which affect depreciation operate, and secondly to an integrated industry, showing how the programmes for writing off the investments in the industry can be co-ordinated and the economic assessment of new projects facilitated in consequence. The effects of varations in the value of money are also considered.

The propositions are illustrated by numerical examples, drawn, in the case of the application to an integrated industry, from the field of public electricity supply.

Date of reading not yet fixed

MONOGRAPHS

Quantitative treatment of three-phase brush-shifting series commutator motor *Monograph* 413U

O. E. MAINER, M.SC.(TECH.)

PREVIOUS quantitative treatments appear to have ignored the loss component of motor current. In this paper, an approximate equivalent circuit, which makes allowance for this component, is

developed from first principles. A method is devised for correcting the errors introduced by the approximate treatment so as to obtain an accurate solution.

The average percentage errors in motor current, power factor and input obtained by both approximate and accurate treatments are given for a wide range of operating conditions.

Algebra and topology of electrical networks *Monograph* 414E

P. R. BRYANT, M.A., M.SC., PH.D.

THE author gathers together the various results and methods used in an elementary algebraic and topological study of electrical networks. Considerations are restricted to networks containing a finite number of lumped resistors, capacitors and self- and mutual inductors.

The result is a connected logical presentation leading, by use of the concepts of incidence, loop and cut-set matrices, to the corresponding nodal, loop and cut-set analysis methods.

The surge corona discharge *Monograph* 415S

R. DAVIS, M.SC., *and* R. W. E. COOK, *with an appendix by* W. G. STANDRING, M.A.

EXPLORATORY experiments are described, followed by an account of a more systematic study of the corona discharge with concentric-cylinder electrodes. From experimental records which relate the charge flow in an external circuit to the applied voltage, the corona current and energy loss were derived. An attempt is made to interpret the observations in terms of modern views on the mechanism of electrical breakdown in gases.

The attenuation by corona of surges on transmission lines is examined in an Appendix.

Temperature rises in electrical machines with sustained variations in load and speed *Monograph* 416U

B. J. PRIGMORE, M.A., M.SC.(ENG.)

A METHOD is presented for obtaining the temperature-rise/time curve for a given machine for an arbitrary sequence of operating currents and speeds; the method is demonstrated to give results for such a run correct to about $\pm 2°C$ in 60°–70°C.

The method is to suppose that the equivalent thermal network of the machine is linear, its temperature/time curve thus being the sum of the temperature/time transient responses for a series of short times δt, successive transients corresponding to the average operating conditions during successive intervals; and then to modify this curve to that for the actual non-linear machine by adding a correction curve which is itself composed of two series of transient responses: one of these allows for the effects of non-linearity due to temperature rise, and is based on the succession of average temperatures, given from the first curve, during the intervals δt; the other allows for the effects of changes in dissipation coefficients due to changes in speed.

The test-bed procedure for obtaining the temperature/time transients for the linear machine, and the corrections for non-linearity, is specified. It is recommended that this procedure, lasting about 36 hours, should be applied to samples of appropriate types of machine.

The indeterminacies of measurements using pulses of coherent electromagnetic energy *Monograph* 417E

R. MADDEN, B.S.

THE measurements, on a single pulse function of electromagnetic radiation, of the position of a scatterer with polar co-ordinates R, ϕ are interdeterminate in themselves. The positional indeterminacies are related by $\Delta R \Delta\phi \simeq \frac{1}{4}\lambda_t$, where λ_t is the wavelength of the source. The relation between the indeterminacies of range R and radial velocity V_r is found to be $\Delta R \Delta V_r \simeq \frac{1}{4}\lambda_t c$.

It is shown that vector position and vector velocity are not measurable simultaneously, and it is suggested that the 3-dimensional measurement problem is basically limited to non-simultaneous measurements which have restrictions in the presence of multiple scatterers. Similarity is noted to the quantum-mechanical problem.

Numerical evaluation of inductance and a.c. resistance with particular reference to electrical machines *Monograph* 418U

R. S. MAMAK, B.SC., *and* E. R. LAITHWAITE, M.SC., PH.D.

THE electric and magnetic circuits of electrical machines are generally so complex that the exact evaluation of such quantities as leakage reactance and a.c. resistance is virtually impossible. With the advent of digital computers, it has become feasible to develop numerical methods of predetermining the flux pattern in such cases.

In the paper, the finite-difference equations for electromagnetic systems are obtained, and the inductance is calculated by integrating the magnetic vector potential over conducting surfaces. The same finite-difference equations are applied to the calculation of a.c. resistance of conductors in slots. The use of the method is illustrated by examples of standard transformers, a tap-changing transformer, calculation of the leakage reactance of salient-pole alternator windings and the screening of d.c. poles in a new type of oscillating synchronous linear machine.

Frequency spectrum distortion of random signals in non-linear feedback systems *Monograph* 419M

PROF. J. C. WEST, PH.D., D.SC., J. L. DOUCE, PH.D., M.SC., *and* B. G. LEARY, B.E.

THE authors consider the distortion introduced by torque saturation in a servomechanism responding to a randomly varying input signal, with emphasis on the spectral distribution of this distortion. It is shown that low-frequency errors are produced by the application of an input signal whose spectrum extends beyond the pass-band of the system.

An approximate expression is derived which enables the magnitude of the low-frequency errors to be evaluated in a simple manner. Experimental results are presented for a particular system.

Fire research

EXPLOSIONS and flame marked the Press preview of the British Fire Research Station's new buildings and laboratories at Boreham Wood, Herts., which were officially opened on the 4th November 1960.

The proceedings began mildly enough with an address by the Director of Fire Research, Mr. D. I. Lawson, who explained that the station was a joint undertaking, financed by both the Department of Scientific and Industrial Research and various insurance companies. A conducted tour of the new structures and facilities followed.

One interesting application of electronics to fire-fighting research was a temperature analogue, used to solve heat-flow problems by the electrical simulation of building materials under heat stress. The device co-ordinates a voltage rise with, for example, the increase of temperature inside a burning building to determine the amount of insulation required to provide an adequate safety margin.

Then came the fireworks—aluminium powder was detonated in glass tubes, propane gas was exploded in lengths of duct, foam was employed to extinguish an oil blaze, and a wind tunnel provided a 10m.p.h. gust to increase the spread-rate of fire in a miniature wooden crib.

As a finale, a jet-engine inert-gas generator was demonstrated, filling the area with mechanical screams and thick clouds of vapour, by which firebrands were seen to be extinguished.

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (OCTOBER 1960)

See the Journal for October 1960, p. 616

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (NOVEMBER 1960)

F. AXON, D.C.M., *and* O. H. BARRON, M.B.E., B.SC. PAPER 3213E, APRIL 1960 **Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services** *November 1960*

R. CHASTE, ING.É.S.É., L.ÈSSC., *and* P. CASSAGNE, ING.É.N.S.T., L.ÈSSC. PAPER 3251E, APRIL 1960 **Henri de France colour-television system** *August 1960*

Discussion on **The application of transistors to line-communication equipment** before the North Staffordshire Sub-Centre

C. C. EAGLESFIELD, M.A., Y. KLINGER, PH.D., *and* L. SOLYMAR. PAPER 3305E **A new H_{10}-to-H_{20} mode transducer** *November 1960*

PROF. H. E. M. BARLOW, B.SC.(ENG.), PH.D. PAPER 3318E **Non-reflecting waveguide tapers** *November 1960*

J. K. SINHA, M.SC., PH.D., *and* J. BROWN, D.SC.(ENG.). PAPER 3316E **A new cavity-resonator method for measuring permittivity** *October 1960*

G. V. GEIGER, B.SC., N. D. LA FRENAIS, B.SC.(ENG.), *and* W. J. LUCAS, M.SC. PAPER 3319E **Propagation measurements at 3480 and 9640 Mc/s beyond the radio horizon** *November 1960*

A. R. DONALDSON, B.SC., I. P. FRENCH, B.SC., *and* D. MIDGLEY, B.SC., PH.D. PAPER 3311E **Paraboloidal reflectors with axial excitation** *November 1960*

Communicated discussion on **A physical classification of electromagnetic waves**

D. L. RICHARDS, B.SC.(ENG.), *and* G. A. BUCK. PAPER 3338E **Telephone echo tests** *November 1960*

A. F. HARVEY, D.PHIL., B.SC.(ENG.). PAPER 3315E **Industrial, biological and medical aspects of microwave radiation** *October 1960*

PROF. T. KILBURN, M.A., D.SC., PH.D., *and* R. L. GRIMSDALE, M.SC., PH.D. PAPER 3178M, JANUARY 1960 **A digital-computer store with very short read-time** *August 1960*

PROF. T. KILBURN, M.A., D.SC., PH.D., D. B. G. EDWARDS, PH.D., M.SC., *and* D. ASPINALL, M.SC. PAPER 3302M **A parallel arithmetic unit using a saturated-transistor fast-carry circuit** *August 1960*

D. B. G. EDWARDS, PH.D., M.SC., M. J. LANIGAN, M.SC., *and* PROF. T. KILBURN, M.A., D.SC., PH.D. PAPER 3307M **Ferrite-core memory systems with rapid cycle times** *August 1960*

G. R. HOFFMAN, PH.D., B.SC., D. H. SMITH, M.SC., PH.D., *and* D. C. JEFFREYS, M.SC. PAPER 3217M, FEBRUARY 1960 **High-speed light output signals from electroluminescent storage systems** *August 1960*

T. C. CARDWELL, B.SC.(ENG.), J. R. W. SMITH, M.SC., *and* G. H. KING, B.SC. PAPER 3219M, APRIL 1960 **An experimental transistor-controlled component selection and testing machine** *July 1960*

F. E. WHITEWAY, B.SC. PAPER 3294E **The recording of high-speed single-shot phenomena** *November 1960*

B. J. DAVIES, B.SC.(ENG.), R. C. ROBBINS, B.A., C. WALLIS, B.SC., *and* R. W. WILDE, B.SC. PAPER 3312M **A high-resolution measuring system using coarse optical gratings** *November 1960*

Discussion on **Subscriber trunk dialling** before the Western Centre, the Tees-Side Sub-Centre and the Northern Ireland Centre

PART C. MONOGRAPHS (SEPTEMBER 1960)

See the Journal for September 1960, p. 561

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

CHARLES PHILIP COOTE-CUMMINS

Charles Philip Coote-Cummins who died in Barbados on the 8th March 1960 was born on the 9th January 1871. He commenced his electrical engineering career in the Royal Navy, having passed out of Osborne, Isle of Wight, but unfortunately on his contracting an extremely bad attack of yellow fever had to retire. He then attended a two-year course at City and Guilds of London Central Technical College, and was apprenticed to Sir William Preece, engineer-in-chief to the Post Office.

For more than 20 years he was principal of Pembroke Urban District Technical Schools. In 1918 he became a partner in R. N. Eaton and Co., Dublin, and in 1921 joined William Tatlow and set up offices as consulting engineers where he practised successfully for some years, still remaining principal of the technical schools although relieved of teaching duties. He then decided to branch out into the commercial world, considering it to be more profitable than advisory work.

He left Ireland in 1955 and purchased a delicatessen shop in the dock area of Liverpool from an army man who, after having made a considerable fortune in the business, wished to retire. He also bought a palatial residence in the Sefton Park area for a song, owing to the Hatry crash. The house was broken up into flats, the ground-floor flat being kept for his own use, and this proved to be a very profitable scheme. Meanwhile, the shop, under the management of his niece, did well, but the idea of a 'chain' scheme, under the management of a man who was inexperienced in the business, was his downfall and he was in a short time a ruined man.

He was a most adventurous and likeable person and had many friends in Dublin. He was of an inventive turn of mind and made a successful attempt at automatic lighting of a country house. He was married, but had no children.

He joined The Institution as an Associate in 1897 and was elected an Associate Member in 1899 and a Member in 1921. He served on the Dublin Local Section Committee in 1900–01 and on the Irish Centre Committee from 1921 to 1928, being vice-chairman from 1922 to 1924 and chairman in 1924–25. His paper entitled 'Technical training of electrical artisans' was published in the *Journal* in 1907.

S. L. R. P.

SIR ARTHUR FLEMING

The death of Sir Arthur Percy Morris Fleming, C.B.E., D.ENG., LL.D., Honorary Member, Faraday Medallist, and Past-President of The Institution, on the 14th September 1960 will have saddened all who are concerned with the improvement of our national facilities for engineering education and training, and most of all those many thousands of men who were privileged to benefit from the schemes of apprenticeship which he pioneered within Metropolitan-Vickers Electrical Co. over 50 years ago.

He was born at Newport, Isle of Wight, in 1881 and was educated at Portland House Academy, Newport, and at Finsbury Technical College, London. After working as an improver with the London Electric Supply Corporation and as a test-room assistant with Elliott Brothers, Lewisham, he was selected by British Westinghouse, later Metropolitan-Vickers, Manchester, as one of the 'holy 40', to undergo a course of training with Westinghouse

Electric and Manufacturing Co. at its East Pittsburgh works. On joining the Manchester company, he was engaged as a specialist in electrical insulation and soon became chief designer, and then superintendent and chief engineer, of the Transformer Department.

It was not long before he introduced arrangements for the systematic training and further education of the young men in this department, and from this beginning grew the Education Department of which he became director. He often said that the most important raw material of industry was its young people, and he devoted himself to ensuring that his own young people, from the embryo craftsman to the university graduate, were recognized and treated as such. They came from all over the world, for in the sphere of industrial training the names of Fleming and Metro-Vickers became international bywords; and there can hardly be a country in which there are not several, indeed many, men who hold 'A.P.M.' in honour and who would welcome the opportunity to express their deep gratitude for his efforts on their behalf.

His influence and inspiration in this sphere penetrated widely within the electrical industry as a whole, and the benefits they have brought to the progress of the industry have been profound.

His far-sighted views on engineering education and training were matched by his realization of the need for research within industry, and especially for research which was not bounded by the problems of existing products. He therefore began to create a research department within the company, to which he attracted a succession of men of outstanding ability and who responded to his inspiration by making many notable contributions in pure as well as applied science. A particular example of his remarkable foresight was his forceful contribution to the establishment of radio broadcasting in this country. He retired from his directorship of research and education in 1952.

Fleming's outside interests and activities were manifold. He was a member of the Council of the University of Manchester, of the Governing Body of Imperial College, of the Delegacy of the City and Guilds of London Institute, of the Ministry of Education Committee on the Training of Teachers and Youth Leaders, and of the War Cabinet Engineering Advisory Committee; chairman of the Electrical Engineering Committee of the Central Register of the Ministry of Labour, of the Athlone Fellowship Committee of the Board of Trade and of the Federation of British Industries Overseas Scholarships Committee; and president of both Sections G and L of the British Association, and of the British Association for Commercial and Industrial Education. He also played an important part in the establishment of the Department of Scientific and Industrial Research and of the Electrical Research Association.

He was awarded the Hawksley Medal by The Institution of Mechanical Engineers in 1937 and the Universities of Manchester and Liverpool conferred honorary doctorates upon him; he was appointed a Commander of the Order of the British Empire in 1920 for his contribution to submarine detection; and he was knighted in 1945 for his services to education.

He was predeceased by his widow in 1948 and is survived by two sons and a daughter.

He joined The Institution as a Student in 1898 and was elected an Associate Member in 1905 and a Member in 1911, and within all his interests it occupied a place of special importance. He became a member of Council in 1932, a Vice-President in 1935 and President in 1938; and for his outstanding services to the profession he was awarded the Faraday Medal in 1941 and elected an Honorary Member in 1952. He served on the Manchester Local Section Committee from 1908 to 1911 and was vice-chairman of the North-Western Centre in 1917–18, chairman in 1918–19 and an *ex officio* member in 1946–47 and from 1939 to 1943. He served on the Education and Training Committee from 1946 to 1951, being chairman in 1946–47 and 1948–49, on the Research Council Committee from 1946 to 1948 and on the Joint Committee for Practical Training from 1946 to 1955. He was awarded the John Hopkinson Premium jointly with R. Johnson for their paper entitled 'Chemical action in the windings of high-voltage machines', which was published in the *Journal* in 1911. He delivered the Faraday Lecture in 1937–38, entitled 'The evolution of electrical power', and the Students' Lecture in 1934, 1935 and 1946. Some of his many papers were published in the *Journal* in 1908, 1915, 1918, 1919 and 1939. W. J.

A memorial service for Sir Arthur Fleming was held in the Queen's Chapel of the Savoy on the 4th October 1960. Among those present were members of his family, Mr. H. T. Young, Mr. J. R. Beard, Sir Noel Ashbridge, Sir John Hacking, Sir Harold Bishop, Sir Josiah Eccles (Past-Presidents), Mr. A. H. Mumford, Mr. C. T. Melling, Mr. O. W. Humphreys, Mr. B. Donkin (Vice-Presidents), and other members of Council. The service was conducted by the Chaplain to the Council, the Rev. C. L. Cresswell, K.C.V.O., M.A., and an address was given by Sir Willis Jackson (Immediate Past-President).

SAMUEL HENRY FOWLES

Samuel Henry Fowles who died on the 19th July 1960 at Croydon, Surrey, was born on the 20th September 1886. He was educated at Godmanchester Grammar School and then apprenticed for two years to Dick, Kerr, London, followed by part-time study at Armstrong College and Erith Technical Institute while receiving further practical experience with the Scottish Electric Power Co., Falkirk, and as mains assistant with Dewsbury Borough Council. Thereafter the whole of his working life was spent with municipal electricity undertakings.

He was from 1914 to 1915 with Erith Urban District Council as mains and distribution engineer; from 1915 to 1916 with Aylesbury Borough Council as chief assistant engineer; from 1916 to 1917 as chief engineer, Leek Urban District Council; from 1917 to 1924 with Sunderland Borough Council as resident engineer; from 1924 to 1927 with Chesterfield Borough Council as deputy borough electrical engineer; from 1927 to 1929 with Ilkley Urban District Council as borough electrical engineer and manager; from 1929 to 1932 with Loughborough Borough Council as borough electrical engineer and manager; and from 1932 to 1948 with Heston and Isleworth Borough Council as borough electrical engineer and general manager. Following vesting day he continued to serve with the Southern Electricity Board until his retirement in 1952.

He was an individualist and had great strength of character, which was particularly evident from his foresight and leadership in civil-defence matters during the 1939–45 War. He was held in high regard by his staff and local authorities. His main interest and hobby was music, particularly choral. He was the possessor of a fine baritone voice and could always be relied on as a vocalist at all social occasions.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1937. He served on the East Midland Sub-Centre Committee from 1931 to 1934. His paper entitled 'The production of power from blast-furnace gas' was published in the *Journal* in 1920. He was also a Member of The Institution of Mechanical Engineers. R. H. W.

HAROLD WESTON

Harold Weston, O.B.E., who died suddenly on the 8th September 1960 was born in St. Helens, Lancashire, on the 10th October 1896. He was educated at Cowley Grammar School and part-time at Gamble Institute, St. Helens, and at Liverpool University.

After receiving practical training with Pilkington Brothers, Doncaster, he joined Cammell, Laird of Birkenhead for a year and then the Cleveland and Durham Power Co., Middlesbrough. Most of his professional life, however, was spent in the service of the Belfast Corporation, which he entered in 1923 as power-station shift engineer at the then newly erected harbour power station under the management of the late Sir Johnstone Wright. At the time of his death he had attained the position of generation engineer in charge of all the power stations operated by the Belfast Corporation.

A specialist in the sphere of generation, his outstanding ability and his services to the electricity supply industry in Northern Ireland were recognized in 1956 when he was appointed an Officer of the Order of the British Empire.

Meticulous in every task which he undertook, he always strove for perfection and encouraged it in others. A kindly man with a keen sense of humour, he endeared himself to all who knew him, not only to his colleagues and the staff under his control, but to a wide circle of friends that his genial personality attracted to him.

In his earlier life he was no mean cricketer, wielding the willow with considerable skill and bowling a useful off-break ball. Apart from his professional life he was probably best known, however, as a photographer of the highest order, and many hundreds of enthusiasts in Northern Ireland owe much to the assistance and advice which he so generously gave them in the art of taking pictures. He is survived by his widow and three sons.

He joined The Institution as a Student in 1918 and was elected an Associate Member in 1923 and a Member in 1951. He served on the Northern Ireland Centre Committee from 1947 to 1953, being vice-chairman in 1951–52 and chairman in 1952–53. He was a past-president of the Belfast Association of Engineers. R. P. W.

SOME RECENT BOOKS

HIGH VOLTAGE DIRECT CURRENT POWER TRANSMISSION

C. ADAMSON and N. G. HINGORANI

LONDON: GARRAWAY. 1960. 284 PP. £4 4S.

IN recent years, more interest has been shown in h.v.d.c. transmission, largely as a result of the successful operation of the Gotland scheme and the decision to use direct current and not alternating current as was first proposed, for the cross-Channel inter-connection.

The publication of a volume integrating the available information on the topic is therefore timely, and it is fitting that one of the authors should be Mr. Colin Adamson, who has for many years been an enthusiastic protagonist of direct current and who has been mainly responsible for building up a research group at Manchester College of Science and Technology.

The text opens with a general discussion comparing a.c. and d.c. systems. Subsequent chapters deal with convertor circuits, grid control, compounding and regulation, protection, reactive power, earth and sea returns, harmonics, insulators, corona, valves, and d.c. cables. The final section includes an appendix by M. R. Tellier on voltage stress in d.c. cables.

In general, the treatment is comprehensive and up to date, although, in the reviewer's opinion, sufficient attention has not been paid to radio interference. There are several references to interference generated by line conductors and insulators, but the more important question of interference from convertor stations is dismissed in one sentence—'Current surges may also produce high-frequency radio interference near to substations'. In fact, the interference produced by the terminal stations is much more intense than by a.c. substations, and special measures may have to be taken to suppress it.

The book is at its best when dealing with specific d.c. problems, although there is some evidence of inadequate background in the more general discussions of transmission techniques. Nevertheless, it should prove a useful reference work for transmission engineers and for postgraduate students studying the subject. J. S. FORREST

NUCLEAR FUSION

W. P. ALLIS (*Editor*)

NEW YORK: VAN NOSTRAND. 1960. 488 PP. £4 14S.

AT the 1958 Conference on the Peaceful Uses of Atomic Energy, the results of five to ten years' research in controlled thermonuclear reactions were openly discussed for the first time by an international body of scientists. Over 100 papers were presented by the United States, the Soviet Union, the United Kingdom, and other nations. These have previously been recorded in full in two volumes of the official report of the conference. Prof. Allis has now given us an abridged edition. This he has done by careful selection of the more important papers, by adding clarifying sentences, and by cutting out parts wherever he felt this to be necessary.

The material has been rearranged into 11 chapters. The first contains the survey papers. This is followed by four sections covering theory, diagnostics and general properties of plasmas. Finally, there are six chapters devoted to thermonuclear devices.

Each section is supported by an impressive list of references; a complete list of the conference papers on nuclear fusion is also given. It is perhaps unfortunate that papers on thermonuclear reaction rates, energy balance, and cyclotron radiation were excluded from this edition. The editor's comment that energy-balance studies seem premature surely cannot be accepted—conservation of energy still holds good.

In retrospect, the main impact of the conference was to impress on the scientific world the vast amount of research which has to be done in basic plasma physics, and in technology, before thermonuclear power is a practical proposition.

There are mixed views on how this should be achieved, although perhaps the choice is not so wide as is sometimes supposed. There is universal agreement that magnetic confinement is the starting-point, with a first rough division into magnetic mirror machines and toroidal devices. The problems in the former would appear to be injection, confinement and heating; whereas, in the latter, instabilities and unexplained power losses are the main source of concern. It will be readily agreed that Prof. Allis has succeeded in highlighting the main features of the conference by his careful and skilful classification of material. W. WALKINSHAW

ADVANCES IN COMPUTERS—Vol. 1

F. L. ALT (*Editor*)

NEW YORK: ACADEMIC PRESS. 1960. 316 PP. $10

PROGRESS in the field of digital computers is so rapid that it is difficult to keep abreast of developments.

'Advances in computers' is specially welcome, because its object is to fill the gap between the numerous published papers and the textbooks. In this first volume, there are six topics with the emphasis primarily on computer applications. 'General purpose programming for business applications' describes special programming systems which have been devised for business use, and schemes for dealing with files on magnetic tape. The second chapter on 'Numerical weather prediction' is a very specialized and mathematical account, accompanied by 99 references.

'The present status of automatic translation of languages' is critically reviewed by Bar-Hillel, the article being originally sponsored by a United States Government department. The next two sections, on 'Programming computers to play games' and 'Machine recognition of spoken words', give an up-to-date description of two exciting and important fields in which the potential power of modern high-speed computers is just

becoming apparent. The final article is a formal account of 'Binary arithmetic' and deals with such operations as division in some detail.

Many of the authors are well known, and all the contributions are of a high standard. This book has much to commend it.

R. L. GRIMSDALE

WAVE PROPAGATION IN A RANDOM MEDIUM

L. A. CHERNOV

McGRAW-HILL. 1960. 168 pp. £2 18s.

INHOMOGENEITY is to some extent a characteristic property of every real medium, and wave propagation, both acoustic and electromagnetic, in such a medium is of much present interest. This book, and that by V. I. Tatarsky on propagation in a turbulent medium—also translated in the same series—together provide a comprehensive survey of important Russian work in this general field.

Chernov's publication falls into three main parts. The first section presents a study of the basic problem using the ray approximation, and is confined to the case where the scale of the inhomogeneities is large compared with the wavelength. The second, and most extensive, part contains a discussion of the diffraction theory of wave propagation; finally, there is an examination of how fluctuations in the incident wave affect the image formed by a focusing system, a matter of much interest in hydro-acoustics and astronomical optics. The mathematics is developed mainly in scalar form, as in acoustics, but the modifications necessary for the vector counterpart appropriate to electromagnetic waves are indicated.

This is essentially an advanced theoretical treatise, though comparisons with experimental data are made on a number of points. Its appeal in the radio-engineering field is likely to be confined to research workers on wave propagation, who should find it—and particularly the second part—useful and stimulating.

J. A. SAXTON

PHOTOCONDUCTIVITY OF SOLIDS

R. H. BUBE

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 461 pp. £5 18s.

THE author, a major contributor to the field of photoconductivity and luminescence, has presented a unified picture and interpretation of photoconductivity phenomena, deriving examples from many different materials, and has shown the correlation between photoconductivity and other related photo-phenomena in insulators and semiconductors. As Dr. Rose says in the foreword, 'in the light of the improved understanding of photoconductivity and its growing importance, both as a scientific tool and as a basis for new devices, the time is propitious for reviewing the field in book form'.

A brief historical survey is first given, with the emphasis almost entirely on studies since the Second World War. Sections on electron processes in crystals and photoconductivity processes follow. Three chapters, on the preparation of photoconductors, electrode effects, and imperfections, containing many references, are particularly attractive features for engineers. About 40% of the text is concerned with detailed examinations of electronic processes involved in the photoconductivity of solids (e.g. energy bands and mobility, scattering, trapping, and recombination processes) and with theoretical approaches to an understanding of the subject. The final section summarizes several closely related topics (e.g. photovoltaic and photo-electromagnetic effects). An appendix surveys photoconductor applications.

Written in a clear and attractive manner, the work lists over 1000 references and contains about 230 excellent illustrations. It is a comprehensive publication which can be highly recommended. Its greatest value will be to graduate and postgraduate engineers entering the field of photoconductivity and to the research worker in allied fields.

F. A. BENSON

ELECTRICAL ENGINEERING SCIENCE

P. R. CLEMENT and W. C. JOHNSON

McGRAW-HILL. 1960. 588 pp. £3 14s.

THIS book deliberately breaks away from what has become the traditional approach to studies of this subject and makes a very creditable effort to present the treatment in a more unified form, placing special emphasis on the close relation which exists between the analyses of the problems discussed. In doing that, the authors make most effective use of physical models, applying these pictorially to help interpret their arguments, so that the work should appeal strongly to engineers.

After examining the basic concepts of electric and magnetic fields in free space, the effect of introducing into the field a material medium, such as a conductor, a semiconductor or a dielectric, is considered. Circuit theory is then developed in some detail, supplemented by discussions, as they arise, of the principles of energy conversion, measurement, transients, non-linear systems, transformers, and polyphase networks.

The whole treatment is well conceived and, so far as it goes, successfully carried out. There is, however, a weakness exhibited by the tendency to avoid giving the same consideration to behaviour at high frequency as at low. Thus the chapter on measurement is definitely deficient in this respect, and so is the section devoted to skin effect. The essential principles governing energy conversion are dealt with in a clear and concise way, but it seems a pity that the opportunity has not been taken to introduce an additional section on the kind of pumping mechanism used in parametric amplifiers.

The text is illustrated with numerous examples, which are generally well chosen, but there are one or two captions that might lead to misunderstanding. For example, in Fig. 13.18, the statement appears 'B increasing into paper', intending to indicate the direction of B and not to imply, as it does, a changing flux density.

The importance of an integrated and unified treatment of electrical engineering science cannot be overemphasized, because this is undoubtedly the most helpful way open to us of bringing the study of the topic within manageable proportions. The authors have taken a valuable new step towards

that objective, and they are to be congratulated, together with their publishers, on their achievement.

H. M. BARLOW

RADIOACTIVE WASTES: THEIR TREATMENT AND DISPOSAL

J. C. COLLINS

E. AND F. N. SPON. 1960. 239 PP. £2 15S.

THIS volume discusses the sources, treatment and disposal of radioactive wastes, with supporting chapters on the nature, measurement and hazards of radioactivity.

The importance of the matter stems from the fact that the generation (the White Paper target) of 4500 MW-days of electricity per annum will create an equilibrium quantity of 660 million curies of strontium 90 and annual arisings of about six million gallons of acid active waste; keeping all this stuff under control will be a major technical/administrative problem in the field of public health.

This is the first authoritative work on the subject, and reviewing it has been a pleasure. It contains a large amount of information concisely presented and well co-ordinated, and each of the ten contributions has the unmistakable backing of extensive experience. Every engineer with responsibility in the field of nuclear energy should read this book, while the section on the discharge of radioactive effluent to the atmosphere will interest every non-nuclear engineer who has a chimney-stack problem. A particularly welcome feature is the large number of references supporting each chapter.

B. L. GOODLET

V.H.F. LINE TECHNIQUES

C. S. GLEDHILL

EDWARD ARNOLD. 1960. 60 PP. 12S. 6D.

THIS work is concerned primarily with the use of the Smith chart in the solution of typical transmission-line problems. The first chapter outlines the basic properties of the chart, and the remaining sections are devoted mostly to various matching techniques, both broad and narrow band. A number of worked examples are presented, and the text is liberally illustrated.

Engineers specializing in the design of microwave components or systems will find in this book a refreshing re-exposition of a subject with which they are already at least somewhat familiar. The novice, however, will react unfavourably to the manner in which the author follows his opening statement on p.1 of the basic transmission-line equations (involving nine symbols) with the casual remark '. . . where all the symbols have their usual meanings'. No further definition is given. At the other extreme, it is perhaps unfortunate that no attention is called, even in the bibliography, to the work of George Deschamps and others in the application of the Smith chart to more complex problems than are dealt with by the author. Within the compass of these two limitations, the volume will nevertheless appeal to a wide range of readers.

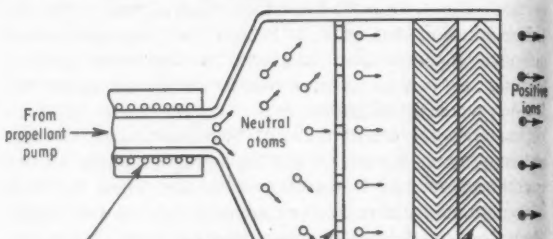
J. M. C. DUKES

PROPULSION SYSTEMS FOR SPACE FLIGHTS

W. R. CORLISS

McGRAW-HILL. 1960. 300 PP. £3 17S. 6D.

THE methods of propulsion appropriate to space vehicles intended for different purposes are first discussed in general terms, and the problems of generating power in space are considered. In one type of propulsion system, the energy is derived from chemical sources, from ion recombination, from nuclear fusion, or from thermonuclear reactions. In another type, use is made of the electrical acceleration of ions of plasmas, of the energy of particles emitted in radioactive decay, or of the pressure of radiation either emitted from the vehicle or absorbed from the sun.



Schematic of a contact-potential ion source, exaggerated in the horizontal direction

The basic principles of each method are next described shortly, and the possibilities of each for space propulsion are examined, usually with graphs which illustrate the performance of the method in different conditions. No attempt is made to show how these graphs were derived; indeed, there is no detailed analysis of any one system. The book is interesting as a wide, and rather superficial, survey of the most advanced thinking on the subject; but the serious reader will wish to follow up some of the numerous references if he is to understand the detailed significance of much that he reads.

J. A. RATCLIFFE

PRINCIPLES OF ILLUMINATION

H. COTTON

CHAPMAN AND HALL. 1960. 526 PP. £3 15S.

PROF. COTTON has added to his several textbooks one which claims to cover the syllabus for illuminating engineering in Part III of the Institution Examination and 'to meet the needs of the practising engineer'.

Of the 18 chapters, five deal with elementary optics and radiation physics, usually covered elsewhere. Other sections discuss the eye; some fundamentals of illuminating engineering; illumination from point, line and surface sources of uniform luminance; colour; photometry; and lamps. There are, finally, three chapters only on illuminating engineering: on the calculation of illumination and on daylight and on

street lighting. The reader is, however, given little or nothing on projectors of any kind or on their application or photometry; on the design of reflectors or refractors; on louvres; or on properties of surfaces, interreflection, adaptation or atmospheric optics.

The treatment is largely a series of theorems on light, often in much detail. They have some bearing on the kind of question often set in examinations to test a student's understanding of principles; but principles should flow from practice and should lead to it, and the author does not communicate a clear feeling for the subject; it might be thought that his experience had lain elsewhere.

He does not pick out methods which are valuable in practice; the many quotations are undiscriminating, and some have been misunderstood or their point missed. There are many misprints, mistakes, and misleading statements and arguments which will confuse the student, and even such a simple apparatus as the prism binocular is wrongly described and illustrated. In a textbook, this is inexcusable.

The best chapters are those on colour and lamps, though parts of these are confusing. The volume is well printed and produced, and for the most part well illustrated; the English style is usually acceptable; the index is fair. But it cannot be recommended as a textbook.

J. M. WALDRAM

THE METRE AND THE SECOND

On the 14th October 1960, at the 11th General Conference of Weights and Measures in Paris, the metre was redefined and measurement of the second ratified.

The metre

Since 1927, the Prototype had been supported by the wavelength of the red line of cadmium in air, and, initially, the conference had decided to use the line as a standard, merely altering the value to its equivalent in a vacuum by applying the formula for dispersion in normal air. However, reports submitted to the Consultative Committee in 1957 provoked reconsideration, and, after careful weighing of the influences on wavelength and symmetry of line of such factors as electric current, pressure, temperature and element-impurities, it was finally decided to use the orange line of krypton for the purpose of wavelength measurement.

Thus, the new definition of the metre reads:

'The metre is equal in length to 1 650 763·73 wavelengths of the radiation in a vacuum corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton86 atom.'

The International Committee of Weights and Measures say that the radiation should be obtained by means of a hot-cathode discharge lamp containing krypton86, at least 99% pure, in sufficient quantity to ensure the presence of solid krypton at a temperature of 64°K. The lamp should be furnished with a capillary tube of inner diameter between 2 and 4 mm and wall thickness of about 1 mm. It is estimated that the wavelength of radiation emitted by the positive column is equal (to within about 1 part in 10^8) to the wavelength corresponding to the transition between the undisturbed levels, when:

(1) the capillary tube is observed as the luminous rays employed proceed from the cathode to the anode;
(2) the lower part of the lamp containing the capillary tube is immersed in a refrigerated bath kept at the temperature of the triple point of nitrogen, to within 1°K; and
(3) the current density in the capillary tube is $0{\cdot}3 \pm 0{\cdot}1$ amp/cm^2.

The second

At the same time, the conference ratified the definition of the second, in force since 1956 as follows:

'The second is the fraction 1/31 556 925·9747 of the tropical year for 0 January 1900 at 12 hours ephemeris time.'

In addition, the conference, appreciating that experimental work during the past few years proves that a standard of time interval based on the transition between two energy levels of an atom or a molecule is both practicable and capable of reproduction with extremely high precision, and regarding an atomic standard of time interval to be indispensable for the requirements of advanced metrology, urged national laboratories and international experts in this field to pursue their studies as actively as possible, and invited the international committee to co-operate without delay with interested international organizations and to co-ordinate the work with a view to permitting the 12th general conference to take a decision on this matter.

British Nuclear Energy Conference

DETAILS of two forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1960

NOVEMBER 30–DECEMBER 2 *Wednesday*(9.30 a.m.)–*Friday*

Sponsoring society: The Iron and Steel Institute
Place of meeting: Church House, London S.W.1

SYMPOSIUM ON STEELS FOR REACTOR PRESSURE CIRCUITS

Some 20 papers, giving the results of recent research in Canada, Great Britain and the United States, will be presented and discussed during the meeting's five sessions. These will cover high-temperature properties; corrosion; fabrication aspects; irradiation effects; and steels for future reactors. Further details may be obtained from the Secretary of The Iron and Steel Institute, 4 Grosvenor Gardens, London S.W.1

DECEMBER 7 *Wednesday*(2.30 p.m.)

Sponsoring society: The British Nuclear Energy Conference
Place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

SYMPOSIUM ON THE DOUNREAY FAST REACTOR

Information on the papers to be presented at the symposium was published in the October 1960 issue of the *Journal of the B.N.E.C.* Further details are obtainable from the Secretary of The Institution of Mechanical Engineers

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

ADAMSON, C., and HINGORANI, N. G. 621.315.024

High voltage direct current power transmission*

London: Garraway, 1960. pp. xvi, 284. 26 × 19cm. £4 4s.

A general comparison of a.c. and d.c. systems is given in the first chapter. Thereafter the book deals with convertor circuits, grid control, compounding and regulation protection, reactive power, earth and sea returns, harmonics, insulators, mercury-arc valves, and d.c. cables. This book is reviewed on page 664.

GOLDSMID, H. J. 537.32

Applications of thermoelectricity

London: Methuen. New York: John Wiley, 1960. pp. xv, 118. 17 × 10·5cm. 10s. 6d.

In this Methuen Monograph it is explained that, by using thermocouples consisting of semiconductors, refrigeration by means of the Peltier effect and also reasonably efficient thermoelectric generation have become possible.

GROB, B. 537

Basic electronics

New York and London: McGraw-Hill, 1959. pp. ix, 524. 23·5 × 15·5cm. £2 10s. 6d.

This book is intended for first-year students taking a technicians' course in R.C.A. institutes and is a practical introduction to the principles of electricity and of electronic circuits.

HELSTROM, C. W. 519.2

Statistical theory of signal detection*

Oxford and New York: Pergamon Press, 1960. pp. viii, 364. 21·5 × 14cm. £3 3s.

A mathematical approach to detection, in the presence of random noise, of radar and communication signals. This book was reviewed in the July 1960 *Journal*, p. 448.

ILLUMINATING ENGINEERING SOCIETY INC. 628.9

IES lighting handbook; the standard lighting guide. **3rd edition**

New York: Illuminating Engineering Society, 1959. pp. xi, 924. 23 × 15cm. £4

A comprehensive American work with chapters on the physics of light, vision, nomenclature, standards, measurement, interior and exterior lighting and special applications. The data are largely in the form of tables and diagrams.

JONSCHER, A. K. 621.315.59

Principles of semiconductor device operation*

London: G. Bell, 1960. pp. viii, 168. 23 × 15cm. 30s.

This is an attempt to bridge the gap between books on the properties of semiconductors and those on circuit applications of transistors. It deals with injection, transport, and decay of excess carriers in semiconductors. This book was reviewed in the July 1960 *Journal*, p. 448.

MARTON, L. (*Editor*) 621.38

Advances in electronics and electron physics—Vol. 12*

New York and London: Academic Press, 1960. pp. xii, 397. 23 × 15cm. £4 6s.

This volume is a record of the proceedings of a symposium on image tubes and related devices held in London in September 1958.

D'AZZO, J. J., and HOUPIS, C. H. 621–52

Feedback control system analysis and synthesis*

New York and London: McGraw-Hill, 1960. pp. xii, 580 24 × 15·5cm. £5 4s. 6d.

Presents the principles for obtaining differential equations for electrical, mechanical and hydraulic systems and the classical methods of solving the equations. Various methods of analysis, including the Nyquist stability criteria, are then explained and compensation techniques to improve performance described. In the last chapter, experimental techniques are related to the methods discussed. This book was reviewed in the August 1960 *Journal*, p. 502.

KAYE, J., and WELSH, J. A. (*Editors*) 621.362

Direct conversion of heat to electricity*

New York and London: John Wiley, 1960. pp. ix, 353. 23·5 × 15cm. £3 10s.

A collection of papers presented at a summer school at the Massachusetts Institute of Technology, covering high-vacuum and low-pressure thermionic engines, magnetohydrodynamic convertors, semiconductor devices and fuel cells. This book will be reviewed in a future issue.

LEVINE, D. 621.396.96 : 912

Radargrammetry*

New York and London: McGraw-Hill, 1960. pp. xxi, 300. 23·5 × 16cm. £4 13s.

It deals mainly with the application of airborne radar to ground mapping, and in detail with sources of error and with matching the p.p.i. radar display to an area on the ground and to the various forms of map projection. The elementary theory of radar returns and aspects of design of airborne radar for mapping are discussed. This book will be reviewed in a future issue.

ELECTRIC SUPPLY AUTHORITY ENGINEERS' INSTITUTE OF NEW ZEALAND 621.315.1

The lineman's handbook

Wellington: Electric Supply Authority Engineers' Institute of New Zealand, 1959. pp. viii, 229. 22 × 14cm. 20s.

This is both a training manual and a general reference handbook. It gives the theoretical basis and the approved methods of carrying out the practical work of a linesman.

LION, K. S. 621.317

Instrumentation in scientific research; electrical input transducers*

New York and London: McGraw-Hill, 1959. pp. xv, 324. 24 × 15·5cm. £3 14s.

Many devices are described in this comprehensive survey of electrical transducers used in research for the measurement of mechanical and electrical quantities, magnetic fields, temperature and radiation. This book was reviewed in the June 1960 *Journal*, p. 377.

VISSER, A. (*Compiler*)

Elsevier's telecommunication dictionary in six languages: English/American, French, Spanish, Italian, German and Dutch

Amsterdam, London and New York: Elsevier, 1960. pp. 1011. 23 × 15cm. £7 7s.

Contains most of the commonly used words and phrases. The foreign equivalents are shown against the English terms, which are arranged alphabetically and numbered. Alphabetical indexes for each of the other languages refer to these numbers. This book was reviewed in the June 1960 *Journal*, p. 379.

KOTEL'NIKOV, V. A. 519.2

The theory of optimum noise immunity*

New York and London: McGraw-Hill, 1959. pp. xi, 140. 26·5 × 18cm. £2 18s.

A translation of the author's 1947 Russian doctoral thesis. It deals with the statistical theory of signal detection and considers code signals and speech. This book was reviewed in the April 1960 *Journal*, p. 243.

NEETESON, P. A. 621.396.615

Vacuum valves in pulse technique. 2nd edition

London: Cleaver-Hume Press, 1959. pp. viii, 195. 22·5 × 15·5cm. 27s.

A mathematical work which indicates the methods of determining the behaviour of a network in which electronic tubes are used as switches. It deals with the triode and the pentode, and a considerable part of the book is devoted to bistable, monostable and astable multivibrators.

NIGHTINGALE, A. 612 : 621.3

Physics and electronics in physical medicine*

London: G. Bell, 1959. pp. x, 292. 22 × 14cm. 30s.

The first part of this book explains the basic principles in mechanics, hydrostatics, heat and electricity, including thermionic amplifiers and other electrical devices used in medicine. Physiological effects of electricity are then described, together with the principles of the electrical equipment used clinically. This book was reviewed in the June 1960 *Journal*, p. 378.

REEVES, E. A. (*Editor*) 662 : 621.3

The uses of electricity in the oil industry*

London: Ernest Benn, 1960. pp. 296. 23·5 × 15·5cm. £2 10s.

A practical reference work covering the variety of uses of electricity in oilfields, refineries and tankers. It indicates where British practice differs from that in other countries and pays particular attention to safety requirements. This book will be reviewed in a future issue.

REYNER, J. H. 50

The universe of relationships

London: Vincent Stuart, 1960. pp. vii, 130. 22 × 14cm. 25s.

The author discusses some of the more remarkable patterns which have been revealed by science, and relates them to the much greater patterns implicit in religious and esoteric teachings. Apart from its deeper significance, this book is a very readable survey of the laws of chemical bonding, atomic theory, vibrations, magnetism, etc. To be reviewed.

SAY, M. G. (*Editor*) 518.5

Analogue and digital computers*

London: George Newnes, 1960. pp. viii, 308. 22·5 × 14·5cm. £2 10s.

This was written by a panel of specialists and is intended for the newcomer to the computer field, but the subject is presented in a practical manner with circuit diagrams and illustrations of equipment. This book will be reviewed in a future issue.

SCROGGIE, M. G. 621.315.59

Fundamentals of semiconductors*

New York: Gernsback Library, 1960. pp. 160. 22 × 14cm. $4.60

A simple explanation of the theory of semiconductors and a useful introduction to the more advanced literature on the subject. It also explains how the special properties of semiconductors are being applied in transistors, photocells and other devices.

WHITROW, M. (*Editor*) 014 : 043

Index to theses accepted for higher degrees in the universities of Great Britain and Ireland—Vol. 8, 1957–8

London: Aslib, 1960. pp. xii, 173. 24 × 15cm. 21s.

OTHER PUBLICATIONS

AUTOMATIC TELEPHONE AND ELECTRIC CO.

The magnetic drum as a subscribers' call recorder, and automatic accounting device. Engineering Bulletin 533, Issue 1

London and Liverpool: Automatic Telephone and Electric Co., 1960. pp. 11. 27·5 × 21cm. n.p.

BETTRIDGE, B. R. A.

Transistors circuits and servicing. 2nd edition

London: Trader Publishing Co. Ltd., 1960. pp. 27. 22 × 15cm. 3s.

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

Torsion devices; a survey of their design, construction and use, by P. J. Geary. A survey of instrument parts—3. Research Report R. 249

Chislehurst, Kent: B.S.I.R.A., 1960. pp. 142. 24 × 15cm. 21s.

PERGAMON PRESS

Silicon carbide; a high temperature semiconductor. Proceedings of the conference on silicon carbide, Boston, Massachusetts, 2nd–3rd April 1959 (edited by J. R. O'Connor and J. Smiltens), sponsored by the Electronics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts

Oxford, London, New York and Paris: Pergamon Press, 1960. pp. 521. 25·5 × 19cm. £4 10s.

IBM WORLD TRADE LABORATORIES (GREAT BRITAIN) LTD.

Bibliography on thermoelectricity, compiled by M. J. Goodall and J. E. R. Young. Bibliography no. 1

Winchester: IBM World Trade Laboratories (Great Britain) Ltd., 1960. pp. 72. 28 × 22cm. n.p.

INTERNATIONAL CONFERENCE ON MEDICAL ELECTRONICS

Medical electronics. Proceedings of the second international conference on medical electronics, Paris, 24th–27th June 1959, edited by C. N. Smyth

London: Iliffe, 1960. pp. 614. 25·5 × 16cm. £7 5s.

This will be reviewed in a future issue.

INTERNATIONAL ELECTROTECHNICAL COMMISSION—INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Report of the plenary session held in the Hague from the 18th to 21st November 1958

Geneva: International Electrotechnical Commission [n.d.] pp. 150. 21 × 14·5cm. £2

INSTITUTION OF CHEMICAL ENGINEERS

Proceedings of the joint symposium on instrumentation and computation in process development and plant design, London, 11th–13th May 1959

London: Institution of Chemical Engineers, 1960. pp. 175. 27·5 × 21·5cm. £4

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 1st October 1960

ELECTIONS

Associate Members

ADAMS, James Sydney, B.SC.
ARROWSMITH, John Richard, B.SC.(ENG.)
BENTON, Arthur Douglas
BRAAE, Rolf Norman
BROWNING, Shane Cairnes, B.SC.(ENG.)
BULLOCH, Walter
COPISAROW, Alcon Charles, B.SC.
GREEN, Henry Victor
HEATH, Brian Thomas
HULTON, Leslie James, M.A.
McCORMICK, Russell Cormac, B.A., M.SC.
MIDGLEY, Denis, B.SC., PH.D.
PENNEY, Donald Sidney
POOLE, Burnet Minifie
SINGH, Maj. General Harkirat, M.A., I.E.M.E.
SWALLOW, Reynold Frost, B.SC.
TAKACS, Jeno, DIPL.-ING.
TINSON, Leonard Percy
URRY, John Thomas, B.ENG.
VENEDIGER, Peter, B.SC.
WALKER, Alexander, B.ENG.
WILLIAMS, Dafydd Archard Vaughan, B.A.
WORMALD, Robert Richard

Companion

SPENCER, Oscar Alan, C.M.G., B.COM.

Associates

BRADBURY, John James
CABLE, Grenville Victor
LANMAN, Rudolph James
LEFEVRE, Raymond
SMITH, John Washington

TRANSFERS

Associate Member to Member

CHALLIS, William Sidney
CRUICKSHANK, Arthur James Ogilvie, B.SC., PH.D.
FEINBERG, Raphael, DR.-ING., M.SC.
FORD, William Perrins
HARMAN, Robert Charles, O.B.E.
HUDSON, Charles Stanley, B.SC., PH.D.
MARSH, Arthur Hireson
MORGAN, Alan Maynard, B.SC.(ENG.)
PHILLIPS, Philip Carthew, B.SC.(ENG.)
PRATT, William Thomas, B.SC.(ENG.)
SPENCER, Frederick Elliot Vickery
SURMAN, William Leonard
SUTTLE, Group-Capt. Charles Edward Pulham, B.SC.(ENG.)
SZAFRANSKI, Stanislaw, B.SC., ING.DIPL.
THOMPSON, Frederick Charles, PH.D., B.SC.
WOLFF, Herbert Werner, B.SC.
WORMELL, Herbert Thomas, B.SC.(ENG.)

Associate to Companion

BUNTING, John Shepherd Allison

Graduate to Associate Member

AINLEY, Keith
ALDWORTH, Ernest Harold
ALLINGTON, Peter John Samuel, B.SC.
ALSOP, Charles Francis, B.ENG.
ANDERSON, Trevor James, B.SC.
BASS, Patrick
BOOTH, Graham Herbert, B.SC.(ENG.)
BOWER, Kenneth John
BRADLEY, Russell Terence
BRUCE, Ronald John Charles, B.SC.
CHADWICK, Allan John Francis
CHAUDHRY, Bashir Ahmad
CONANT, Charles Richard, B.SC.(ENG.)
COWAN, Claude Isaac, B.SC.
DE REDDER, Max, B.SC.
DE SILVA, Totawatte Don Manual Aelian, B.SC.(ENG.)
DRANSFIELD, Desmond
DUMVILLE, Alan John, B.SC.TECH.
DUNK, Desmond Sydney
DYER, Harold Ernest
EAST, Francis Glanville
EDMONDSON, Keith Leonard, B.SC.(ENG.)
EDMONSTON, John Stuart, B.SC.(ENG.)
EMBLETON, Desmond Victor
EMSLEY, Thomas Forrest
FISHER, Colin Varndon
FRERK, Lionel Clive Walter, B.SC.(ENG.)
FROST, Ian Barry Vaughan, B.SC.
FUTERS, Stephen
GALE, Kenneth
GLEDHILL, John Trevor, B.SC.
GODDARD, Dennis Alexander
GOLD, Roy Charles
GOPSILL, Clarence Anthony
HALLAM, Derek
HANCOCK, John Gordon, B.SC.(ENG.)
HANDFORD, Norman, B.SC.(ENG.)
HARFLETT, Ernest George
HARMSWORTH, Jack Albert
HASSAN, Abdul Mannan
HIPWELL, Peter Humphrey, D.F.H.
HODGKINSON, Harold Roy
HUSSEY, Reuben Theodore, B.SC.(ENG.)
HYMANS, Anthony Jack, M.SC.
JACKSON, Frank Walton
JANIK, Wladyslaw Jozef, B.SC.(ENG.)
JOHNSON, Hubert Thomas Coombes
JOHNSTONE, Ian Archibald
KONAREK, Janusz
LEGG, John, B.SC.(ENG.)
LYNCH, Eugene Bernard
MACGREGOR, Gregor
McKIBBIN, Hugh, M.SC., PH.D.
MANNING, Victor Royston
MARLAND, Henry Sidney
MENSAH-BROWN, Joseph Paschal Kweku, B.SC.(ENG.)
MITCHELL, Bernard George
MORRIS, Noel Malcolm, B.SC.
NEVIN, Barry James
NORTON, Anthony
O'MAHONEY, Patrick Gerard
PARKER, William Frederick

Graduate to Associate Member (continued)

PENNELL, Philip Maurice
PURSSELL, Robert Francis
RICHARDSON, Colin Charles
RIISNAES, Harold James, B.SC.(ENG.)
ROBERTS, Richard William, B.SC.(ENG.)
ROBINSON, Geoffrey Thomas Graham
SAGGERSON, John Kenneth, B.ENG.
SEEGER, Ingo
SEPHTON, Robert Martland
SHORT, Thomas
SHROFF, Dossabhoy Hormusji, B.SC.(ENG.)
SIEMASZKO, Zdzislaw Antoni, DIPL.-ING.
SILCOX, John Eastlake
SMITH, Geoffrey Frank
STEVENSON, Neale Geoffrey
THOMAS, Walter Adekanmbi Ladipo
THOMPSON, Anthony St. Maur, B.SC.(ENG.)
VICKERS, Gerald Howard
VIVIAN, Frank George, B.ENG.
WATKINS, Christopher Michael James, B.SC.(ENG.)
WESTON, Bryan Henry
WILDE, Peter, B.SC.(ENG.)
WILLIAMS, Joseph Scott
WRAITH, Charles Peter Robin, B.SC.(ENG.)

The following elections and transfers approved by the Council of The Institution are effective from the 6th October 1960

ELECTIONS: 1st LIST

Graduates

AIKEN, Roger George, M.E., B.SC.
APPLEBY, John Terence
BARKER, Cyril Glyn
BATES, Brian
BONNICK, Bryan John
BRITTON, Peter John, B.SC.(ENG.)
CLARKE, John, B.SC.(ENG.)
DOSHI, Babulal Mohanlal
EDWARDS, Kingsley
GOH, Seng Kim
JOUBEILY, Youssef, B.SC.(ENG.)
LANGFORD, Thomas David, B.E.
LAWDER, Capt. Robert Ernest, B.SC.(ENG.), R.E.M.E.
LUMSDEN, Alan McLeod
ROLFE, Robert Leopold
ROWLAND, John Kenneth
SADLER, Richard Ralph Stewart, B.SC.
SANDFORD, Eric
SCHUSTER, Bernard Frederick, B.E.

Students

AGGARWAL, Girdhari-Lal Hanuman-Das
BOND, Richard
BRADFORD, Michael John
BURGESS, Rex Neil
COOPER, Paul
FELDMAN, Jeffrey Malcolm
FRETWELL, Michael Peter
GHANEKAR, Hari Anant, B.SC., B.E.
GHOSE, Mukul, B.E.
GOUWS, Etienne Hjalmar
HAWES, Kevin John
HOFMAN, Ronald
HOGG, David Langdon
JEFFERIS, Thomas Martin
LEEKHA, Ram Prakash, B.A., B.E.
MATHUR, Subodh Chandra
MILLER, John Hillman
MOLENAAR, Gosse Bote
MUTHUCUMARANA, Nissanka Kumarasinghe
OVERSHOTT, Kenneth James
PATEL, Arvind Kantilal, B.E.
POLLITT, Richard Graham
SENARATNE, Ananda
URRY, Clare Curwen
WARD, Michael Henry Evans
YOUNG, Alan

TRANSFERS: 1st LIST

Student to Graduate

ADAMSON, Daniel Welsh, B.SC.
ALLEN, Keith David, B.SC.
ALLSOP, Gerald Anthony
ANSDELL, Arthur Anthony
ARUMUGAM, Kandiah, B.SC.
ASHDOWN, Michael Bryan
AZE, Peter David Thomas, B.SC.
BAIN, George Edward McGregor, B.SC.(ENG.)
BALDWIN, Richard Timothy
BANKS, Peter John
BARKER, Alan, B.SC.TECH.
BARKER, Norman Stuart, B.SC.
BARNES, Donald
BARNETT, Christopher Frank
BEARNE, Keith Paul Whineray
BEATUS, Claude
BEAUMONT, Jack
BENNETT, Roger Stephen, B.SC.
BENNIE, William Lyon
BENTHIN, Louis
BEST, Cyril Frank
BOND, Malcolm
BOOTH, Roy Sims, B.SC.
BOWRING, Stewart David
BOWSKILL, David John
BRAUDE, Bernard, B.SC.
BRENNAN, Francis Michael
BREWSTER, Peter James, A.H.-W.C.
BROOKS, Lyn Alan, B.SC.
BROOM, Colin Edward
BURTON, Godfrey Raymond
CALLENDAR, Michael Hugh
CASSERLEY, David John
CATON, Dennis James
CAVANAGH, Eric Joseph, M.A.
CHARLETT, Paul Francis
CLARK, Brian James
CLARK, John Charles
COPLEY, Alan, B.SC.
COULBECK, Bryan
COX, Bernard Ronald
CRADDUCK, Trevor David
CRAGGS, Peter Arnold
CROWE, Leslie
CROWTHER, Neil Graham
CRUICKSHANK, James McNicol
CURTIS, Brian William
DAGLESS, John Leslie, B.SC.(ENG.)
DAY, Gary Mervyn
DEAKIN, Barry
DRYER, Sydney
DWYER, Alfred
EAST, George Frederick
ELLIOTT, Robert Lennox
EVANS, Kenneth Stuart, B.SC.
EVANS, Ronald Herbert James Pugh
FAIRBROTHER, Leslie Ronald
FALCONER, John, B.SC.
FEATHERSTONE, David Hooton
FELLINGHAM, Robert Geoffrey
FELLOWS, Kenneth Gordon
FROW, Roger
GARDNER, Michael George
GATISS, John William, B.A.
GEERE, Ronald Durston
GEORGE, Royston Arthur
GERRARD, George Alan
GLEAVES, Casson Dawson, B.SC.
GNANASABESAN, Subramaniam, B.SC.

Student to Graduate (continued)

GOBLING, David Samuel, B.SC.
GUNAWARDENA, Jaya Abeysingha
GUNDLACH, Alan Michael, B.SC.
HAKEEM, Mohammad Amanul, B.SC.
HALL, Edgar Ronald, B.SC.
HALLIWELL, David Anthony
HAND, Geoffrey
HARI, Govindbhai, B.SC.(ENG.)
HARMER, Daniel Sidney, B.SC.
HARRIS, John Cecil
HARRIS, Meurig, B.SC.
HARRISON, Peter
HEATH, John Edward William
HEIM, Peter Simon, B.SC.
HELLIWELL, Alan James
HICKLING, Brian George
HILL, Bryan James
HINKS, Peter
HODGKINSON, Raymond Thomas
HOLLAND, Brian Alfred, B.SC.(ENG.)
HOLLAND, Ian Malcolm
HUNTER, William Alexander, B.SC.
INGLESFIELD, Rodney, B.SC.
IRVING, Philip Byron
JACKSON, David Arfor
JACKSON, David Gibson, B.SC.
JONES, Alan Charles
JONES, Kenneth, B.SC.
JORDAN, James Redmon
KEATINGE, Peter Anthony Terence, B.SC.(ENG.)
KENT, Allen Dewhurst
KIDD, David Alan, B.SC.
KING, David Christian, B.SC.
KNIGHT, James
KRAJEWSKI, Mark
LAVENDER, Anthony William
LAVENDER, William Anthony, B.SC.
LEE, Wing Kee
LEWIS, John Rainsford
LOVERIDGE, John Edwin George
McATAMNEY, Peter James, B.SC.TECH.
McTIGHE, Anthony Norman
MANTON, Colin Brian
MARTIN, Raymond Geoffrey
MEHRTENS, David Henry, B.SC.
MIAO, Chi
MIDDLEMISS, John Johnston
MOAT, Alistair Cooper
MORFIELD, Raymond Edward
MORRIS, David Joseph, B.SC., DIPL.ENG.
MOSES, George Edward
MUIR, Neil David
MUKHERJEE, Phanindra Nath, B.SC.
NELSON, Adrian William
NORTON, Michael Alfred
NWANKWO, Francis Agunnia
OLDROYD, David Brian
O'SHEA, Thomas Gerard Augustine, B.SC.
PARKER, Alan
PARKER, Bernard Sydney
PILLAY, Ratnam Kandaswamy, B.E.
PITCHES, Ronald, B.SC.TECH.
POLKINGHORNE, Michael John
PONTING, Philip James
POOLEY, Christopher
RAINE, William, B.SC.
RATA, Paul Joseph Harry, B.SC.(ENG.)
REID, John Peter
RICHARDSON, Colin Albert Stanley
RILEY, John Netherwood, B.A.
ROBERTS, John Stanley
ROBERTSON, John William, B.SC.
RODGERS, David Alexander
ROGERS, Keith David
RYE, John
SANDRASEGARAM, Sampanther, B.SC.
SANTHIRAN, Ganapathipillai
SCOTT, David Iain
SEDGWICK, Anthony
SHELDON, Neville Thomas
SHINGLES, Godfrey Stephen, B.SC.
SMITH, Andrew Martin
SMITH, Gordon Reginald
SNOW, Frederick Albert, B.SC.
STANSFIELD, James Neil
STICKELLS, Frederick George
TAMBE, Pratap Shripad, B.SC.
THOMPSON, Gordon, B.SC.TECH.
THURBIN, Patrick John
TIMMIS, Albert Gerald, B.SC.
TODD, Robert John
TOPLISS, John Peter, B.SC.
TOWERS, Alan, B.SC.(ENG.)
TRUCKELL, Antony George
TRUMAN, Norman Nathan, B.SC.
TURNER, Michael John Bainbridge, B.SC.
TYPE, Arthur Michael
UNDERWOOD, Justin Dowsett
VELSAMY, Appathurai
VINCENT, Dudley Joseph
VIVEGANANTHAN, Parampalam
WAINWRIGHT, Anthony
WAINWRIGHT, John Roy, B.SC.
WALES, John, B.SC.
WALKER, David John
WARD, Kenneth
WARDLE, Terence Newton
WATKINS, Brian John
WHEATLEY, Barry
WHITAKER, Barry Stuart, B.SC.
WHITEHOUSE, David John, B.SC.
WHITESIDE, John Johnston, B.SC.
WHITING, John Percy
WHITWORTH, Robert Edward, B.SC.TECH.
WICKS, Stuart Edward
WILBY, William Peter Lanham, B.SC.(ENG.), PH.D.
WILCOCK, John Slider
WILEBORE, Derek
WILLIAMS, John Cyril
WILMAN, Hugh
WILSON, Derek Robert, B.SC.TECH.
WILSON, John Law
WOOLGAR, Anthony John, B.A.

ELECTIONS: 2nd LIST

Graduates

ALGHALI, Muhammad Omar
CHAPMAN, Ian Bowes, B.SC.
CHARLTON, Lt. David James, B.A., R.N.
CONNOLLY, James Alexander
DUDDELL, Frederick Arthur, B.SC.
DUTTA GUPTA, Ranjit Ranjan, B.SC., M.SC.TECH.
EDWARDS, Ronald James, B.SC.
FRASER, James
GRAHAM, Gerald Vincent, B.SC.
KING, John Elton
MARSH, Leonard Maurice
MONTEIRO, Alfred Peter
MURTY, Devarakonda Venkata Satyanarayana, M.SC.
NICE, Capt. Richard Keith, R.SIGNALS
NICHOLAS, Andreas Michael
OAKLEY, Denis Frederick, B.SC.(ENG.)
O'ROURKE, Peter John
PERERA, Marcus Vincent Romanis, B.SC.(ENG.)
PLUMMER, Capt. John Deane, M.A., R.SIGNALS
ROSS, Robert Ian, B.SC.
PAW, Maung Htin, B.SC.(ENG.), M.S.E.
SACHDEVA, Gulshan R., B.A.
SAMNAKAY, Abdul Rashid Mohamed
SINGHA, Bindhyeshwari Prasad, B.SC.(ENG.)
STARLING, Donald Sidney
STERRY, John William
WARDMAN, Derek
WINGHAM-KYNASTON, John Arthur
WHITFIELD, Alexander Henry

TRANSFERS: 2nd LIST

Student to Graduate

MONTGOMERY, Anthony Yalden, B.ENG.
PARSONS, Bruce Raymond, B.SC.(ENG.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

November 1960

22 *Tuesday* V. FURUSKOG *and* G. F. KENNEDY, M.A. 'The Aswan hydro-electric scheme' (Joint Meeting with The Institution of Civil Engineers at The Institution of Civil Engineers, Great George Street, London S.W.1)

E 22–24 *Tuesday* (10a.m.)–*Thursday* Conference on electronic telephone exchanges (all wishing to attend are required to register; forms available on application to the Secretary of The Institution)

ED 28 *Monday* PROF. G. H. RAWCLIFFE, M.A., D.SC., *and* G. A. V. SOWTER, PH.D., B.SC.(ENG.), will open a discussion on 'Training for research'* (at 6 p.m., tea at 5.30 p.m.)

E 30 *Wednesday* W. J. BRAY, M.SC.(ENG.). Lecture on 'The potentialities of artificial Earth satellites for radiocommunication'†

December 1960

O 1 *Thursday* W. R. STEVENS, B.SC., *and* H. M. FERGUSON. Lecture on 'Our civic lighting: gloom or gaiety?'‡ (Supported by a paper (3260U) by W. R. STEVENS, B.SC., *and* H. M. FERGUSON entitled 'A survey of street lighting and its future' *synopsis:* May 1960)

MED 2 *Friday* G. H. BYFORD, PH.D., *and* K. G. WILLIAMS, M.A., M.R.C.S., will open a discussion on 'Telemetering biological data'* (at 6 p.m., tea at 5.30 p.m.)

I 5 *Monday* BRIG. C. A. ZWEIGBERGK, C.B.E., M.C., M.SC.TECH., will open a discussion on 'National proving of domestic electrical equipment'*

M 6 *Tuesday* PROF. D. GABOR, F.R.S., W. P. L. WILBY, PH.D., *and* R. WOODCOCK, PH.D. 'Universal non-linear filter, predictor and simulator which optimizes itself by a learning process' (paper 3270M) *synopsis:* July 1960

U 8 *Thursday* J. RAVENSCROFT, B.SC. 'Determination of the electrical characteristics of an arc furnace' (paper 3328U) *synopsis:* September 1960

E 12 *Monday* P. R. BRYANT, M.A., M.SC., PH.D. Lecture on 'Topology concepts in network theory'†

S 14 *Wednesday* L. GOSLAND, B.SC., *and* R. G. PARR, B.SC.(ENG.) 'Basis for short-circuit ratings for paper-insulated cables up to 11 kV' (paper 3314S) *synopsis:* August 1960; G. S. BUCKINGHAM, B.SC.(ENG.) 'Short-circuit ratings for mains cables' (paper 3284S) *synopsis:* July 1960

ED 15 *Thursday* PROF. C. A. MACE, M.A., D.LIT., will open a discussion on 'How to pass examinations, or the psychology of study'* (at 6 p.m., tea at 5.30 p.m.)

M 20 *Tuesday* L. AIREY, B.SC., will open a discussion on 'Digital transducers'†

E 21 *Wednesday* L. J. WARD. Lecture on 'Microminiaturization'†

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

District Meetings

ARRANGEMENTS for District Meetings in November and December 1960 other than in the area of a local Centre

November 1960

READING (at the George Hotel, King Street at 7.15 p.m.)

21 *Monday* G. P. COPPING, B.SC. 'Electronics in the postal mail services'

December 1960

MAIDSTONE (at Maidstone Technical College at 6.30 for 7 p.m.)

5 *Monday* G. E. D. REDMAN 'Uses and manufacture of m.i.c.c. cable'

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH OCTOBER 1960

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	923	9644	19	7
£2 to <£5	2280	6295	14	3
under £2	29085	15292	12	11
		47099	9	9

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

On the nomination of the Association of Supervising Electrical Engineers, the Council have appointed Mr. C. G. Kitchener to serve in succession to Mr. W. F. Parker, MEMBER, on the above committee.

COUNCIL FOR CODES OF PRACTICE

The Council have nominated Mr. C. T. Melling, C.B.E., M.SC.TECH., MEMBER, as their representative on the above council in the place of Col. B. H. Leeson, C.B.E., T.D., PAST-PRESIDENT, who wishes to retire.

CODE DRAFTING COMMITTEE ON ELECTRICAL EQUIPMENT FOR INDUSTRIAL MACHINES—ELCP/28

The Council have nominated Mr. J. O. Knowles, M.A., MEMBER, as their representative on the above committee.

B.S.I. DATA PROCESSING INDUSTRY STANDARDS COMMITTEE

The Council have nominated Mr. H. M. Ross, M.A., ASSOCIATE MEMBER, as their representative on the above new committee.

PANEL OF B.S.I. TECHNICAL COMMITTEE ELE/79—REVISION OF MEMORANDUM ON DOUBLE INSULATION (B.S. 2754 : 1956)

The Council have nominated Mr. Forbes Jackson, MEMBER, as their representative on the above panel.

B.S.I. TECHNICAL COMMITTEE ELE/46—CAPACITORS

The Council have nominated Mr. C. G. Garton, MEMBER, as their representative on the above committee.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY—SYMPOSIUM ON LIGHT DUTY ELECTRICAL CONTACTS APRIL 1961—ORGANIZING COMMITTEE

The Council have nominated Mr. D. A. Weir, MEMBER, and Dr. A. Fairweather, ASSOCIATE MEMBER, as their representatives on the above committee.

ROYAL SOCIETY—BRITISH NATIONAL COMMITTEE FOR PHYSICS

The Council have nominated Sir Willis Jackson, D.SC., F.R.S., PAST-PRESIDENT, as their representative on the above committee for a period of six years from the 1st January 1961 to replace Dr. J. Thomson, M.A., D.SC., MEMBER.

SYMPOSIUM ON THE ADVANCED GAS-COOLED REACTOR—ORGANIZING COMMITTEE

The Council have nominated Dr. J. V. Dunworth, C.B.E., M.A., MEMBER, as their representative on the above committee.

BRITISH NUCLEAR ENERGY CONFERENCE—BOARD

The Council have nominated Mr. F. H. S. Brown, C.B.E., B.SC., MEMBER, as their representative on the above board in succession to Sir Josiah Eccles, C.B.E., D.SC., PAST-PRESIDENT, who wishes to discontinue his service as The Institution's representative.

JOINT COMMITTEE WITH THE ROYAL AERONAUTICAL SOCIETY ON THE APPLICATION OF ELECTRICITY IN AIRCRAFT

The Council have nominated Mr. J. C. Rivett, B.SC.(ENG.), MEMBER, as their representative on the above joint committee in the place of Mr. P. J. Daglish, B.SC., MEMBER.

LANCHESTER COLLEGE OF TECHNOLOGY COVENTRY, GOVERNING BODY

The Council have nominated Mr. C. F. Freeman, B.SC.(ENG.), MEMBER, as their representative on the above governing body.

SOUTHEND MUNICIPAL COLLEGE, ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. H. T. Prior, B.SC.(ENG.), ASSOCIATE MEMBER, as their representative on the above committee.

BIRMINGHAM COLLEGE OF ADVANCED TECHNOLOGY, ADVISORY COMMITTEE FOR ENGINEERING

The Council have nominated Mr. G. F. Peirson, MEMBER, as their representative on the above committee.

INSTITUTION SUMMER MEETING, 1961

A SUMMER Meeting of The Institution will be held in London from Monday, 29th May, to Friday, 2nd June 1961. This will provide an opportunity for members, particularly those from the Provinces, to visit the reconstructed Institution building, where full use will be made of its new facilities.

The programme will include technical visits, tours to places of interest in and around London, and social functions.

Accommodation is being reserved in hotels within easy reach of Savoy Place. Further details will be announced in due course.

CHRISTMAS HOLIDAY LECTURE

AT the invitation of the Council of the Institution, Dr. R. L. F. Boyd, ASSOCIATE MEMBER, will deliver a Christmas Holiday Lecture entitled 'Space research by rocket and satellite'. The lecture, which is intended for boys and girls in the fifth and sixth forms, will be given in the Lecture Theatre at Savoy Place on Tuesday, 3rd January 1961, at 3p.m. and will be repeated at the same time the following afternoon.

Schools in the Home Counties are being invited to apply for tickets, and a number will be reserved for members'

children; members should apply for these by the 1st December 1960, stating for which afternoon they are required. As accommodation is limited, members are asked not to accompany their children.

The following is a synopsis of the lecture:

The envelope of air which surrounds our globe not only provides for our respiration but also protects us from the energetic radiations and particles which continually bombard its outer regions. It is our frontier with space. To a height of a little over 20 miles it can be penetrated by airborne vehicles, but beyond this rockets must be employed if we are to carry our instruments through the frontier. For this reason, the term 'space research' has come to mean the study of the world by means of rocket-borne equipment.

This range of studies extends from the core of the Earth to the distant galaxies and the range of techniques from Geiger counters to rocket-borne telescopes.

The lecture will describe some of the many experiments being carried out as part of the British programme of space research.

SYMPOSIUM ON ELECTRONIC-EQUIPMENT RELIABILITY

THE contributions and discussions at the symposium on electronic-equipment reliability, which took place on the 18th May 1960 (see report on p. 639), will be published this month as a 66-page quarto volume. The prices (post-free) are 12s. 6d. to members of The Institution and £1 5s. to non-members.

Copies can be obtained on application to the Secretary of The Institution.

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution, it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

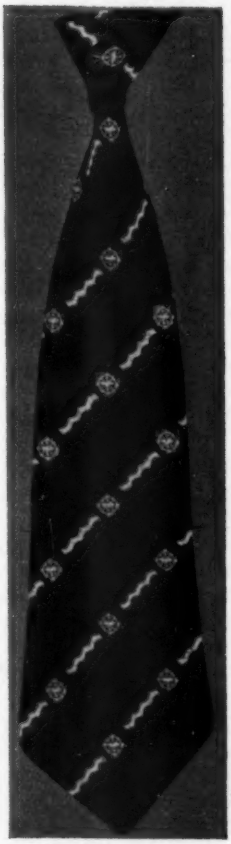
VACANCY ON THE STAFF OF SCIENCE ABSTRACTS

APPLICATIONS are invited for a post on the staff of *Science Abstracts* of an Assistant Editor for *Section B Electrical Engineering*. The duties will consist of selection of articles from the world's literature, allocation to specialist abstractors, editing the abstracts for publication, and preparation of the subject index.

Applicants should have an engineering or science degree or a corresponding qualification, and some knowledge of most branches of electrical engineering. Experience of a research or design department, or of information work connected with such, is desirable. Familiarity with the literature of electrical engineering, and a wide interest in current developments, are essential, together with a capacity for concise expression and orderly arrangement. Acquaintance with foreign languages is essential, for a large part of the work will involve examination of foreign publications.

The starting salary will depend on age, qualifications and experience. Entry to a superannuation scheme would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, London W.C.2, giving full particulars of their education, training and experience.

THE INSTITUTION TIE



SUPPLIES of the Institution tie and of a square (30 × 30in.) of the same design can be obtained on application to the Secretary of The Institution. The charges, which are as follows, are intentionally kept low, but any profit is allowed to accumulate and is then transferred to the Incorporated Benevolent Fund.

Ties:	
silk (heavy quality)	£1 3s. 6d.
Terylene	18s. 0d.
Square:	
Terylene	£2 2s. 0d.

The general appearance of the tie may be seen from the accompanying illustration.

A wavy gold line edged in red, running diagonally across the navy-blue background of the tie, represents wave motion, one of the fundamental concepts of electrical engineering which appear on The Institution's coat of arms.

A shield of light blue—by common consent the predominantly 'electrical' colour—shows a winged golden thunderbolt enclosed in a golden ring bearing golden fleurs-de-lis at the four cardinal points. This alludes to the power of electricity circumscribed and under control; the fleurs-de-lis on the encircling ring make a passing reference to the compass card and thus to our seal and to the work of Kelvin.

ECONOMICS OF DIESEL-ELECTRIC MOTIVE POWER

A PAPER on 'Economic results of Diesel electric motive power on the railways in the United States of America' by Mr. H. F. Brown will be presented and discussed at a meeting of The Institution of Mechanical Engineers at 1 Birdcage Walk, Westminster, London S.W.1, on the 30th November 1960 at 6 p.m.

The attendance of members of our Institution will be welcome.

MEMBERSHIP OF LOCAL CENTRES AND SUB-CENTRES

A MEMBER whose registered address is within the area of a Centre or Sub-Centre is automatically attached to the Centre or Sub-Centre concerned, and also if he is a Student or a Graduate under the age of 28 to any Graduate and Student Section within the area. Any member who so wishes, however, may be attached to any Centre or Sub-Centre adjacent to that in which he resides, if this is more convenient to him, by making a request in writing to the Secretary of The Institution to that effect.

INTERNATIONAL MEASUREMENT CONFERENCE

IMEKO 1961, the international measurement conference, will be held in Budapest from the 26th June to 1st July 1961. An exhibition will be organized in association with the conference.

The preparatory committee of IMEKO have decided to limit the number of papers to be presented at the conference to about 120, divided among the 20 participating countries. The main topics of the conference will be general and specialized questions of scientific and industrial measurement and instruments, including construction, design and manufacturing problems. The Executive Council of the International Federation of Automatic Control have approved proposals to organize a special section for border-line matters in measurement and automation, jointly with IMEKO, at the 1961 conference.

Further information may be obtained from the IMEKO Secretariat, P.O.B. 3, Budapest 5, Hungary.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested when notifying a change of address to give their full initials, their previous address and their class of membership.

VISIT OF I.C.E. PRESIDENT TO WEST INDIES

IN furtherance of the views formulated by the Councils of the three senior engineering institutions, that by a system of rotation more-frequent visits should be paid to Joint Groups and other oversea units of the institutions, the President of The Institution of Civil Engineers, Sir Herbert Manzoni, and the Secretary, Mr. Alexander McDonald, have arranged to visit the Joint Groups in British Guiana and the Caribbean area.

As visualized at present, it is proposed that the party should leave London for Jamaica on the 21st February 1961 and travel to Trinidad on the 28th February. British Guiana will be visited from the 5th to 9th March, after which the party will go to Barbados until the 12th March, and then on to the Bahamas. Departure from Bahamas for London via New York is expected to be on the 15th March.

Arrangements are being made, through the Joint Groups, or senior members of the institutions in places where there are no Joint Groups, for the I.C.E. President and Secretary to meet as many as possible of the members of the three institutions.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council of The Institution, the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary of The Institution, giving the date of his call-up.

WOMEN'S ENGINEERING SOCIETY

THE programme for the 1960–61 session of the London Branch of the Women's Engineering Society includes on the 14th December 1960 a lecture by Capt. F. Potts on 'Power transmission by submarine cable' and one on the 8th February 1961 on 'Space flight' by a speaker from the British Interplanetary Society.

Meetings begin at 7 p.m. (tea at 6.30 p.m.) at Hope House, 45 Great Peter Street, Westminster, London S.W.1, and those interested are invited to attend.

LEVERHULME RESEARCH AWARDS

THE Secretary of the Leverhulme Research Awards invites applications for fellowships and grants in aid of research. The awards are intended for senior workers of established position and are limited to British-born subjects normally resident in the United Kingdom. No topic of inquiry is excluded from consideration, but preference is given to subjects in which the existing provision for research is inadequate. The awards are for between three months and two years.

Application should be made on a form obtainable, together with further details, from the Secretary, Leverhulme Research Awards, St. Bridget's House, Bridewell Place, London E.C.4. The closing date for the receipt of applications is the 31st December 1960. The awards will be announced in May 1961 and will normally date from the 1st September 1961.

MAGNETOHYDRODYNAMICS

A SYMPOSIUM on engineering aspects of magnetohydrodynamics is to be held at the University of Pennsylvania, Philadelphia, Pa., U.S.A., on the 9th and 10th March 1961.

The meeting is sponsored by the American Institute of Electrical Engineers and the Institute of Radio Engineers, and the programme will be concerned with plasmas in the presence of a magnetic field and, in particular, with the engineering aspects of the subject. Four sessions are planned, covering communication and diagnostics, flight applications, fusion, and power conversion.

Further information may be obtained from the Secretary of the Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y., U.S.A.

YMWELIAD I GAERDYDD

As they had recently visited Edinburgh and Dublin, it was only appropriate that in 1960 the Supply Section should go to Cardiff. Those of us who were not familiar with this city were delighted to find that it had one of the finest civic centres we had ever visited. The general impression of the untravelled Englishman that Cardiff consists exclusively of docks and rain was not entirely correct. The rain, however, was with us most of the time—steady and persistent but completely unsuccessful in damping our enjoyment of the visit.

We met on the Thursday afternoon, 29th September, for a visit to Llandaff Cathedral, where we were given a very interesting lecture on the history and architecture of the building before walking round to inspect it. The statue in aluminium by Epstein of Christ Majestis, supported on a parabolic concrete arch, gave us something to argue about subsequently.

We were welcomed at tea by Mr. H. Jackson, Chairman of the Western Centre, in the Banqueting Hall of Cardiff Castle, and were shown round afterwards. We concluded that Cardiff keeps its ruins in a very good state of repair.

And so to a reception at the City Hall, where we were guests of the Lord Mayor of Cardiff (a very charming lady) and the Lady Mayoress (her very charming daughter-in-law). A brilliant occasion.

At the City Hall, Cardiff

(left to right) Mrs. J. R. Mortlock; the Lady Mayoress of Cardiff; Dr. J. R. Mortlock, Chairman of the Supply Section; and the Lord Mayor of Cardiff

Engineers after all

Next day we got down to the idea that we were, after all, engineers (or at any rate most of us did). One party visited the Steel Company of Wales, where they saw the largest blast furnace in Europe tapped and the highest-steam-pressure boiler in operation. They saw 200 tons of steel tapped from a furnace and cast into ingots, and the largest rolling-mill in Europe operated by two white-collared gentlemen who, by flicking miniature switches, threw about a mighty ingot until it was rolled down into a suitably sized slab for the hot mill. This, unfortunately, was not working because it was Friday. Inquiries elicited the fact that Friday is the day when this piece of machinery undergoes its weekly maintenance.

Another party went to the works of Bristol Siddeley Engines Ltd. and Bristol Aircraft Ltd., where they had the thrill of sitting at the controls of a Britannia and the facilities to inspect the revolutionary welded-stainless-steel construction of the D.188 supersonic aircraft, now expected to fly at more than 2000m.p.h. After lunch, they took a quick glance at the Severn 275kV-line-crossing in the rain and finally arrived at Berkeley nuclear power station, where the metal control rods were being inserted into the core of the no. 1 reactor.

Yet a third party visited the works of South Wales Switchgear Ltd. at Blackwood, and the Cwm Colliery.

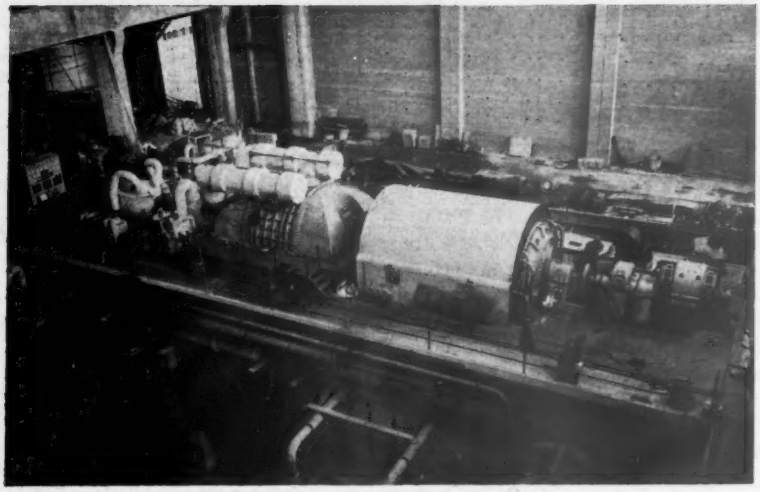
Those who felt that these visits savoured too much of engineering visited the Wildfowl Trust at Slimbridge. They were somewhat reticent about their experiences, but your reporter gathered that an excellent day was enjoyed by the ducks.

Penillion singing

However, after drying off, we all made for the Section Dinner at the Park Hotel, which was followed by a performance of penillion singing by the Parti Cerdd Dant Pontrhydfen. It was explained to us that the secret of penillion singing is that, while the harp plays one tune, the singers sing another, and this seems to be a fair description of it. It is, however, extremely pleasant, and the cheerful spirit of the singers quickly communicated itself to the rest of us, and we thoroughly enjoyed the evening.

Saturday, we were told, was a free day, but we had the opportunity of joining the Western Centre Supply Group in their annual visit, on this occasion to the works of South Wales Switchgear and afterwards to Aberthaw power station. Still in the rain, the party was conveyed to Blackwood by coach and had an extremely interesting visit to the works, where a number of engineering and machining processes, new to a number of us, were demonstrated.

After lunch, as the guests of the company, the party were conveyed to the most southerly point of Wales, where they saw Aberthaw power station in the course of construction. During the return journey the rain stopped, and it was possible to enjoy the beauty of the surrounding countryside.



No. 1 set, Aberthaw power station

Half a crown

Dinner that evening at the Park Hotel was followed by a dance as the guests of the South Wales Electricity Board and the South Wales Division of the Central Electricity Generating Board. The speeches were kept to a reasonable length by an arrangement made by the Chairman, whereby he paid half a crown to any speaker whose speech was less than five minutes, but fined him half a crown for each minute by which his speech exceeded that period.

On Sunday, 2nd October, we were again split up, for a visit to the Pontcanna television studios of T.W.W. Ltd. and a coach trip to Caerphilly Castle, or a visit to the Broadway television studios of the B.B.C., or a coach tour of the Rhondda Valley.

It was a pleasant and light-hearted end to a rather strenuous three days, and we broke up and went home at midday on Sunday with the impression that scenically, civically, industrially, hospitably, in fact in every respect except meteorologically, the Supply Section visit to Wales in 1960 had been an immense success. This was, of course, due to the courtesy and generosity of those who arranged visits and entertained us. They are far too numerous to mention, but it is hoped that all of them will realize how greatly we appreciate everything they did for our edification and enjoyment. J. L. L.

ELECTRONICS AND COMMUNICATIONS

EARTH SATELLITES AND NETWORK THEORY

On Wednesday, 30th November 1960, Mr. W. J. Bray will lecture on 'The potentialities of artificial earth satellites for radiocommunication'. He will discuss the various schemes that have been proposed for providing world-wide communication by means of artificial satellites orbiting the Earth. He will describe systems comprising active and passive satellites in relatively low circular orbits (e.g. 1000–3000 miles above Earth), satellites with highly elliptical orbits (e.g. perigee 200 miles, apogee 1000 miles), and satellites in 22000-mile orbits stationary with respect to the Earth.

He will consider the design, performance and reliability aspects of communication satellites and ground stations and will direct attention to the need for international agreement on the characteristics of satellite systems, particularly in respect of frequency planning and the precautions to be taken to avoid interference to and from other radio services.

Mr. Bray received his early training as an electrical engineer in H.M. Dockyard, Portsmouth. He subsequently attended the City and Guilds Engineering College, London, with Royal and Kitchener Scholarships, gaining a first-class honours B.Sc.(Eng.) degree, an M.Sc. degree and the Diploma of Imperial College.

He joined the Post Office Engineering Department in 1935 and was, until 1954, at the Post Office Research Station, Dollis Hill, London, where he was engaged on radio research and development.

Mr. Bray is now staff engineer of the Radio Planning and Provision Branch (W.I.) of the Post Office Engineering Department, and he is International Chairman of Study Group IX of the C.C.I.R. (Microwave Systems).

He has contributed a number of papers to the *Proceedings* and has been awarded the Ambrose Fleming and other premiums. He is a past-member of the Electronics and Communications Section Committee.

Approach to network theory

On Monday, 12th December 1960, Dr. P. R. Bryant will lecture on 'Topology concepts in network theory'. The lecture will be tutorial, and will attempt to show how, by using concepts and results from graph theory, an approach to network theory is obtained which is systematic, providing a deeper understanding of linear-network behaviour. As a result, new properties of networks have been discovered and new realization methods developed.

Dr. Bryant, who is employed by the General Electric Company at their Research Laboratories, Wembley, was

born in 1929. He obtained mathematics degrees of M.A. and M.Sc. from Cambridge and London Universities respectively. A G.E.C. scholarship, awarded in 1956, enabled him to study network theory at Cambridge and obtain his Ph.D. degree in 1960. Dr. Bryant was awarded the Institution Heaviside Premium for 1959.

News from the Centres

NORTH MIDLAND CENTRE

Primary substations

THE opening meeting of the 1960–61 Session was held on the 4th October under the Chairmanship of Prof. G. W. Carter, 110 members and guests being present. The Chairman welcomed one new Corporate member and presented him with the booklet outlining the aims and objects of The Institution.

Prof. Carter then called on Mr. F. W. Fletcher to deliver his Inaugural Address on the subject of 'Primary substations in the Yorkshire Electricity Board'. The Address was illustrated with many coloured slides which added greatly to the interest. In proposing a vote of thanks, Mr. J. D. Nicholson emphasized the extent of the work, both in the national sense and in the Yorkshire Electricity Board, that Mr. Fletcher had contributed in the developments described in his address.

Seconding the vote of thanks, Mr. J. W. A. Painter said that the forthright way in which Mr. Fletcher had tackled the problems of standardization in the Yorkshire Board was an indication of his approach to the national problems, on which he must have had no small part in the progress which had been made since the nationalization of the supply industry in 1948.

Prof. Carter presented a Certificate of Honorary Secretaryship and a copy of the 'History of The Institution' to Mr. H. A. Carr, the retiring Honorary Secretary, thanking him for the tremendous amount of work he had done and the helpful and courteous way in which it had been carried out. Dr. E. C. Walton then made his customary appeal on behalf of the Benevolent Fund, which raised £23 6s. 9d.

The retiring Chairman, Prof. Carter, then formally handed over the chair to Mr. F. W. Fletcher. In proposing a vote of thanks to Prof. Carter, Mr. A. J. Coveney said there were so many pleasant things he could say about him that it was difficult to choose, but he would refer to his versatility in providing a different Chairman's Address to each section, and the help he had given the Centre through Leeds University.

In seconding the vote of thanks, Dr. G. N. Patchett made many charming references. The vote was carried with enthusiasm, and Mr. Fletcher then presented a Certificate of Chairmanship and a copy of the 'History of The Institution' to Prof. Carter, who suitably responded.

Utilization Group

It was a very misty night when the Utilization Group held a meeting at Huddersfield on the 15th March 1960, but a substantial tea and a good meeting were sufficient compensation. The subject was 'The provision of adequate electrical installations in small industrial premises' by Mr. J. A. Sharp. The colour slides made the newer installations look very attractive.

The concluding meeting of the 1959–60 Session was held at Leeds on the 26th April 1960, when Mr. J. H. Davis read his paper on 'Silicone electrical insulation'. Mr. Davis replied without hesitation to the points raised in discussion and seemed to have no difficulty in getting his tongue round long chemical words. No wonder engineers use contractions such as p.t.f.e.

At the Annual General Meeting of the Centre, it was announced that the Committee of the Group for the 1960–61 Session would be that proposed by the retiring Committee, there being no other nominations. Reference must be made to the resignation of our Honorary Secretary, Mr. E. R. W. Brinkworth. Our sincere thanks are due to him for his past services and our best wishes for his future success.

Hull District Meetings

Five evening District Meetings were held at Hull during the 1959–60 Session. All were particularly well supported, with an average attendance of 42 members and guests, 50% more than the average for the previous session. This reflects the increasing support given to Mr. H. Hilton, the enthusiastic Convener of the meetings. Dr. Patchett, Vice-Chairman of the Centre, visited Hull to present an Institution prize to Mr. Terence Capon at the March meeting.

Dr. G. N. Patchett presenting Mr. T. Capon with an Institution prize

Annual golf match

The annual golf match in support of the Benevolent Fund was held at Sand Moor Golf Club on the 17th May 1960, when 72 members and guests played. The course was in perfect condition, and, in spite of the damp weather, everyone thoroughly enjoyed himself.

The Centre Chairman, Prof. Carter, presided over the dinner following the tournament. This was a light-hearted social occasion for the presentation of the trophies and prizes, Mr. H. Beattie being the new holder of the Woodhouse Challenge Cup. A most enjoyable day came to an end with the usual auction and a gracious expression of thanks by the Chairman to the club officials for the excellence of their arrangements.

H. H.

NORTHERN IRELAND CENTRE

Eventful session

ALTHOUGH your reporter has not made any returns during the session which has just ended, it is hoped that a survey may be regarded as better than nothing, as last session was, in fact, an eventful one.

In October 1959, the Chairman, Mr. T. S. Wylie, gave his Address to a record audience, on the provision of commercial television in Northern Ireland. His treatment of a very abstruse subject so that engineers of every weight and frequency could feel they understood it, without anyone feeling that it was elementary, argued a very carefully prepared lecture by an expert on his subject.

As the year started, so it continued. The provision of adequate electrical installations in buildings, introduced at the November meeting by Mr. C. C. Hyams, was debated at great length by the fortunate few who got the chance to air their views. It was quite apparent that your reporter was not the only frustrated person present when the meeting closed, and we all returned to our own homely, if inadequate, installations, arguing fiercely as we went.

Cybernetics

In December 1959 we had a Christmas treat—all the more enjoyable because it was unexpected, and in fact it was given to us to compensate for a disappointment. Dr. E. R. Laithwaite, scheduled to talk about the linear induction motor, was prevented from crossing the Irish Sea by very adverse weather, and his former colleagues at Manchester, Prof. J. C. West and Dr. J. L. Douce, offered a lecture on cybernetics instead.

The writer cannot now remember what cybernetics is (or are), but he will long remember a lecture, profusely illustrated by demonstrations, arranged at a few hours' notice, every one of which worked like clockwork. Memory getting fainter with the passage of time was graphically compared with memory getting stronger. It did not require the authors to say which way madness lay.

With profound psychology we were then introduced to the automatic control of a model railway. The behaviour of this device was much more predictable than British Railways and much more satisfying. Indeed, half an hour after the lecture concluded, the plaintive bleep of a much overworked locomotive could be heard through a solid phalanx of men round the demonstration bench.

Early in January 1960 we heard about generator/motor problems in pumped-storage installations from Dr. J. H. Walker, and the month ended with the Annual Dinner-Dance on the 29th. At this most enjoyable function we were honoured by the presence of Mr. and Mrs. A. H. Mumford and the Lord Mayor and Lady Mayoress of Belfast (Alderman and Mrs. Robin Kinahan).

'Fresh' air

An informal lecture in February, by Mr. J. E. Martin of the Ulster Hospitals Authority, attracted welcome visitors from the medical and nursing professions. The subject was 'Factors influencing the engineering design of hospital operating theatres'. The preference of senior anaesthetists for explosive anaesthetics and the hazards of 'static' were alike dealt with graphically in the animated discussion, as were the dangers of 'fresh' air and antibiotics. There was lots of fun, but little real agreement between medical and lay men, demonstrating the possibilities of this kind of joint meeting.

An additional meeting was convened in February to hear Dr. Laithwaite's deferred lecture. The consensus of opinion was that it was well worth waiting for. Apart from the paucity of papers on electrical machines, suitable for reading at a Centre, the subject of the linear induction motor has an intrinsic interest. When such a subject is handled by a brilliant natural lecturer, the end comes all too soon.

As in hospitals and health, everyone has a real personal interest in public transport. The paper on 'Recognition of moving vehicles by electronic means', delivered in March by

Annual Dinner-Dance of the Northern Ireland Centre on the 29th January 1960 at the Grand Central Hotel, Belfast

Mr. and Mrs. A. H. Mumford are seated left centre, with Mr. T. S. Wylie, Centre Chairman, and Mrs. Wylie at right centre

Messrs. T. S. Pick and A. Readman, brought along administrators and engineers from the transport world, while the rest of the members present represented the travelling public. A wonderful opportunity was thus offered the latter to tell the former what was wrong with local transport. These comments were, in general, ingeniously included in a serious discussion of a very interesting paper.

Faraday Lecture

In March also we had the pleasure of hearing Prof. M. G. Say deliver the Faraday Lecture on electrical machines. The highest praise possible was given to the Lecture by someone who simply said 'Faraday would have loved it'.

At the April meeting, Mr. D. A. Barron delivered his paper on subscriber trunk dialling. That this topic is of importance to all of us as engineers or just as subscribers was evidenced by the enthusiastic reception the paper received and the discussion it provoked.

The year ended with the Annual General Meeting in May 1960, followed by a fascinating talk by Dr. W. H. Morgan, of the Department of Forensic Science of the Ministry of Home Affairs, on 'Science in the detection of crime'. D. S. M.

SCOTTISH CENTRE

Opening activities

THE opening activities for the 1960–61 Session were clouded by the death, on the 29th September, of a highly respected and well loved member of the Centre, Prof. Bernard Hague of the University of Glasgow, and by the serious illness, during the summer, of the Chairman-Elect, Mr. R. B. Anderson, which prevented his taking up active duties as Chairman for the first few weeks.

At the opening meeting, on the 4th October 1960 in Edinburgh, the chair was taken by Mr. R. J. Rennie, a Past-Chairman, who thanked Mr. J. A. Aked, the retiring Chairman, for the extremely successful way in which he had carried out the duties of his office, which, in addition to the normal widespread activities of the Centre, had included the Jubilee celebrations and the Institution Summer Meeting.

Electricity supply in North of Scotland

Mr. Anderson's Chairman's Address was read by Mr. J. H. P. de Villiers and dealt with the 'History of electricity supply in the North of Scotland'. Mr. Anderson started with a reference to the remarkable fact that, as early as 1890, the monks of the remote Abbey of Fort Augustus were so well acquainted with scientific development as to install in that year an 18kW water-driven and an 18kW oil-engine-driven d.c. generator.

Subsequent small installations of water power and oil installations, the various abortive attempts to secure powers to harness the streams in some of the larger glens, the activities of the Grampian Co., and, finally, the inception and work of the North of Scotland Hydro-Electric Board were all vividly described and, in many cases, illustrated.

The Address was repeated in Glasgow, Dundee and Aberdeen, being read by Mr. T. J. Daniels in Dundee and by Mr. de Villiers in the other cities.

Presentation

A further ceremony at the opening meeting was the presentation to Mr. de Villiers of a certificate marking his retiral, after seven years' service, from the Honorary Secretaryship and Treasurership of the Centre. Very sincere tributes were paid by Mr. Aked on behalf of the Centre, and by Dr. D. S. Gordon and Mr. J. Mendelson on behalf of the South-West and South-East Scotland Sub-Centres, respectively, while a letter was read from Dr. A. J. O. Cruickshank, Chairman of the North Scotland Sub-Centre. All spoke of the outstanding work and enthusiasm of Mr. de Villiers, which had included the very arduous, but highly efficient, organization of two Institution Summer Meetings, at Inverness in 1955 and in Glasgow this year.

In addition to the above, there were two informal tributes from the floor of the meeting, one by Prof. M. G. Say on behalf of the ladies, who wished to thank Mr. de Villiers for his meticulous care in catering for their comfort and pleasure on all social occasions, and the other by Mr. W. B. Laing, who wished to place on record the great debt owed by the Centre to Mary de Villiers, who had not only willingly acquiesced in the immense amount of time that John de Villiers had spent on Institution work but had herself actively and graciously helped at all appropriate times, even to the extent, for one session, of acting as official hostess.

In replying to these tributes, Mr. de Villiers referred to the support he had always received from all members and asked that the same support and encouragement be given to his successor, Mr. David Rollo. E. O. T.

B.B.C. station for SE. Scotland

NEGOTIATIONS are in progress for the acquisition of a site at Dryden Hill, near Galashiels, for the new B.B.C. station for SE. Scotland. The station will transmit B.B.C. television on Channel 1 with vertical polarization, and the frequencies to be used for the v.h.f. horizontally polarized sound transmissions will be: Light Programme, 89·1 Mc/s; Third Programme and Network Three, 91·3 Mc/s; and Scottish Home Service, 93·5 Mc/s.

The area to be served by this station has a population of nearly 100000 people, some 70000 of whom have not hitherto been within range of either service.

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ISAAC, A. C. I. (Port Elizabeth, South Africa)
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KING, A. (Valleyfield, Canada)
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RADIATION PYROMETER

THE United Kingdom Atomic Energy Authority have developed a radiation pyrometer and associated electrical circuits for the continuous measurement of surface temperatures in the range 650°–750° C of metal bars travelling at up to 20ft/min.

A fused-quartz rod serves as the heat-radiation transmission path, one end being shaped like a fish-tail to partly encircle the bars, and the other being connected to a lead sulphide photocell. The rod has two breaks, the first for a rotary radiation chopper to give a chopping frequency of 1000 counts/sec, and the second for a radiation chopper with alternate blades of Perspex and germanium to give a 10c/s chopping frequency.

Furthermore, the rod transmits radiation over the wavelength interval from 0 to $2{\cdot}5\mu$, the Perspex blades of the second chopper from 0 to 2μ and its germanium blades from 2 to $2{\cdot}5\mu$.

The lead sulphide cell thus receives alternate signals at 10c/s on a 1000c/s carrier signal. After amplification and rectification, the two d.c. outputs of the cell corresponding to the two wavelength intervals are switched to a potentiometer and thence to a ratio recorder.

Further information is available from the Patents Exploitation Officer, U.K. Atomic Energy Authority, 11 Charles II Street, London S.W.1.

Second nuclear station for Severn

THE Central Electricity Generating Board have received the consent of the Minister of Power to construct a 550MW nuclear power station at Oldbury upon Severn, Gloucestershire. The site lies on the south-eastern bank of the Severn Estuary, 14 miles north of Bristol and 4½ miles downstream from Berkeley.

Because of the slowing-down of the nuclear programme, the Oldbury station has been postponed from the 1965 to the 1966 programme, and completion in 1966 will still be possible despite the long delay in obtaining consent. Work will start almost immediately.

The Oldbury site is strategically placed to help meet the growing demand for power in central southern England as well as in Bristol and its suburbs.

Only short transmission lines will be needed to connect it to the existing 275kV Supergrid near the Severn crossing, and to the Bristol area.

Advantage will be taken of a rock shelf offshore to create an artificial tidal reservoir of 350 acres which will impound water at high tide.

From this reservoir, large quantities of cooling water can be drawn during low tides. This unusual arrangement will reduce the costs that would normally be incurred in obtaining cooling water from an estuary with as wide a tidal range as the Severn.